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ELECTRIC LIGHTING PROSPECTS.

LORD THURLOW, chairman of the Anglo-American Brush Electric Light Corporation, had a great deal that was very interesting and very comforting to tell his fellow shareholders at their meeting on Wednesday. It is true he did not advise them to divide amongst themselves the £12,885 which it was open to them to divide; but they were very prudent reasons which he urged in favour of the present retention of that sum, reasons which were accepted as adequate by every shareholder present. They know that they have that amount to their credit, available for a 5 per cent. dividend at any moment that may be convenient, provided they are not more unfortunate than they expect to be in the matter of litigation. Even if the worst happens, the £12,885 will probably cover their utmost loss, and they will anticipate no further interference with their receipt of future dividends. The company is now in a thoroughly efficient and paying condition, and with the undoubted progress of electric lighting it promises to become in a short time a very remunerative concern to those pecuniarily interested in it.

But Lord Thurlow's utterances were interesting not only to Anglo-American shareholders. Everybody connected in even the remotest way with the electric lighting industry must experience a feeling of thankfulness at the improved state of the trade generally involved in and betokened by the satisfactory position of the Brush Corporation. Lord Thurlow himself was anxious to point out that progress was not confined to his own company. He instanced the largely increased number of electrical engineers in the country as an indication that electric lighting is marching onwards. In 1883 there were only 57 electrical engineers mentioned in the "Electricians' Directory;" in 1888 the number had risen to 260, and there is every reason to believe that by the end of 1889 this number will be doubled. The Brush president was not above pointing to the success of those who are, in one department, his keen rivals, the Edison-Swan people. They made a large profit on their last year's transactions; that is to say, they sold a large number of incandescent lamps. Now, lamps are not sold in large numbers if they are not to be used, and the use of incandescent lamps involves the employment of various other apparatus, engines, dynamo-electric machinery, leads, fittings, and what not. And if such progress, such profits, are made in the first few months of the revival, what may not be anticipated when the lapse of a little more time permits of the fruition of the vast schemes now under consideration? It is as certain as that the sun which is rising as these words are written will set a few hours hence, that in the course of two or three years an enormous business will spring into existence. Everywhere we see movement—scarcely a town which takes any pride in itself but is bestirring itself to see what the electric light is made of. All will not adopt it—not at once, at any rate—but a large proportion will. We hope, so far as the public lighting is concerned, they will profit by the experience of others, and avoid incandescent lamps. Incandescent lamps are bound to be used for domestic purposes, and it is not unreasonable to anticipate that in half a dozen years time the number of these in use will in many towns equal that of the gas jets now alight each evening. Competition, which, in one form or another, is bound to set in, legal decisions notwithstanding, will bring down the price of the lamps themselves; continual advance in economy and efficiency is being made in the production and conduction of current; and, with wise and economical administration, the time is not far distant when electric light will seriously compete, even in price, with gas at present rates.

THE ELECTRIC RAILWAY BILL.

THE opposition to the Bill for constructing an electric subway railway from Piccadilly to Holborn Viaduct assumed active and aggressive form in the House of Commons on Friday last. The measure being down for second reading, Mr. Seager Hunt moved its rejection on the ground that the railway would injuriously disturb people who had spent large sums of money on property along the route, and would also operate prejudicially upon them by reason of the proposed power to take only such portions of the property as might be required, instead of the whole, as was usually done. He also complained that the whole matter was in the hands of only four gentlemen, who would have the control of four millions of capital. Mr. G. Bruce seconded the motion, protesting against London being further cut up and undermined, declaring that the advantage of the line would be slight, while the public inconvenience would be great, and asserting that except in the case of the toy railway at Brighton electricity had not yet been tested as a motive power. Mr. Leatham Bright, who is one of the sponsors of the Bill, after answering some objections raised as to the suggested founders' shares, and the proposed authority to sell the undertaking to the London County Council, insisted that a line which would give increased accommodation to 60,000 people could only do them good. Incidentally, he mentioned that 1d. fares were to be charged, to compete with the 1d. omnibuses. Sir Robert Fowler, who had presented a numerously-signed petition against the scheme, urged that the Bill ought to be considered not by itself, but in connection with other schemes which would arise out of it, and suggested that a committee should be appointed to consider the whole railway system of the metropolis, and this and similar schemes. Mr. Isaacson protested against members using the machinery of the House to promote companies, "in order to foist their shares on a misguided public;" and Mr. Coghill denounced the Bill as "one of the coolest propositions ever submitted to the House." Mr. Labouchere effectively retorted by enquiring how such Bills could be dealt with except by using the machinery of the House, and expressed the belief that the railway would be of great public advantage. Mr. Courtney (Chairman of Committees) supported the Bill if calculated to benefit the public, and pointed out that questions as to finance, engineering, and so on, could only be decided by a committee, and not by the House. Sir William Harcourt took the same view, reminding the House that after the committee stage the House could still deal with the Bill on the third reading. After this the Bill was read a second time, and will in due course be referred to a select committee. Among the numerous petitioners against the Bill is the United Telephone Company, presumably because of anticipated disturbance of mains and wires, and with the view mainly of obtaining a *locus standi* when the Bill is discussed in detail in committee.

IF the opposition to the electric underground railway scheme rests upon no stronger foundation than that disclosed in the debate (summarised in another column) on the second reading of the Bill, the promoters need have little fear as to the result. The honourable members who wished to reject the measure displayed a singular ignorance, alike of the power of Parliament and of past experience in regard to subterranean railways. To disturb or compulsorily acquire property is no doubt sometimes annoying to owners or occupiers, but without that where would the Metropolitan Railway—or indeed any railway—be? And who can question the benefits that have accrued from the underground system. The few may object to give way to the many, but in such cases they are well paid for it, and as a rule are only too willing to be thus victimised. As to the point that the undertakers are to please themselves how much or how little of any particular property they will take, that power will not be given without searching investigation and ample safeguards. The same may be said as to the management of the capital, whether by four gentlemen or forty; and with respect to the predicted foisting of shares upon the "misguided public," potential purchasers of shares will be able to take care of themselves by the time the whole scheme has been ventilated and examined by a select committee in each House. Mr. Isaacson is a comparatively new member, otherwise he would hardly have objected to the use of the machinery of the House for carrying such measures—for, as Mr. Labouchere put it, how else can such schemes be dealt with? It is difficult to treat as serious the contention that this railway will injure tradesmen by taking customers away—the contrary effect is more likely to ensue. These being the chief grounds advanced against the Bill, it is almost needless to say it was read a second time, to be referred to a select committee. Before that committee meets, Mr. Bruce will do well to study the subject of electricity. After doing so he will not repeat the astounding statement that "except in the case of the toy railway at Brighton electricity has not been tested as a motive power"!

MR. BERNSTEIN and Messrs. Statter & Co. were doubtless pleased to see in the last issue of one of our electrical contemporaries that an attempt is being made to fasten upon them the blame attached to the repeated failures of the Barnet electric lighting installation. We have said before and we most emphatically state it again that the onus rests with the contractors. If the lamps were not all of the ordered candle-power for a given current, why were they ever placed in position and why were not the Statter dynamos tried previously to being set to work at Barnet? It is usual we believe to ascertain whether machinery is in proper condition previous to setting it into practical operation, and if this was not done we really cannot see that any responsibility attaches itself to those who supplied the materials, for these gentlemen can probably point to other places where their apparatus has been used and not found wanting. Indeed, we learn that at Northfleet the Statter dynamo has answered admirably under very severe conditions of usage.

AT almost the very moment of the publication of our last issue, a fierce storm was raging over a great portion of the country which pointedly illustrated one part of our article on the private wires of provincial newspapers. Describing the conditions of hire we mentioned that in the event of interruption, by storm or other circumstances, of direct communication between the London and the head office of a paper having a special wire, the Postal authorities could disconnect the local wire at either end or both ends, and call the operators to the central telegraph offices to work between them as might be practicable. This is precisely what happened on Friday last. One of the earliest results of the storm of wind and snow was the complete failure of telegraphic communication between London and the most important of the midland and northern districts, and also some towns in the south. The private wires of course became useless, and many of the local lines were abandoned for the night. Every effort was made at the central stations to get the press messages through, but for many hours the efforts were futile, and at the best period were but slightly successful, although all the messages were reduced to the narrowest possible limits. To the Manchester and Leeds papers the breakdown was most serious, and after a desperate struggle, the *Manchester Guardian*, which has two wires, was published with the explanation that "the breakdown of telegraphic communication with London through the storm, compels us to go to press without our London letter, *Gazette* news, and a large portion of political and other intelligence." Other special wire papers were in the same predicament. The coincidence between our article upon this system and the prompt illustration furnished by the storm was at least singular.

IT appears to us that the system of the Series Electrical Traction Syndicate is nothing more nor less than that of Short and Nesmith, which was fully described and copiously illustrated in the REVIEW for May 13th, 1887. Of course the details are modified; for instance, in the Northfleet line the conduit is directly under one of the track rails and not in the middle of the road as was the case with the American plan. Still to all intents and purposes the two systems are identical, the circuit diagrams being precisely the same as those used by us in the issue to which we have referred above.

NOTWITHSTANDING the fact that the Northfleet tramway is operated on the lines of the Short-Nesmith plan, the syndicate holds the patents of Profs. Ayrton and Perry and the late Prof. Fleming Jenkin, and these are looked upon as controlling all devices for series working. The line is the only one of its kind in this country, and what is more, the system seems to be eminently practicable. Probably the syndicate would admit that a better place might have been found for an experimental line, and in the opinion of some tramway engineers we met, the central conduit, as used in America, is thought preferable, for several reasons, to that employed at Northfleet. This, however, is open to question, for Mr. Richardson, the chairman of the largest tramway system in the kingdom, stated at the Society of Arts, when Mr. Reckenzaun's paper on electric locomotion was discussed, that one of the greatest troubles tramway companies had to contend with in the matter of public complaints, was the grooved rails, and it would therefore be very undesirable on their part to introduce a third groove in the centre of the track, or, indeed, anywhere else.

ON Wednesday last we, in company with many representatives of the technical press, had the pleasure of inspecting the Northfleet line with two cars in operation. Several trips were made with the most satisfactory results, so far as one could judge, but we were unable to get any data as to the running cost. No difficulty whatever was experienced at the passing places, and the cars ascended considerable gradients, and overcame the difficulties of sharp curves, with great ease. Indeed, we have never before been present at a trial of electrical tramcars which gave such promise of immediate success; but whether this will be borne out remains to be seen, for the advocates of secondary battery and parallel working will doubtless be able to discover some weak points yet to be surmounted. Some considerable vibration was noticeable in the cars, and this may probably be still further felt after the motor gearing has been in action for a month or two longer. In the absence of figures gained in actual practice we can scarcely speak critically of the scheme, but there are several statements in a pamphlet issued by the syndicate which read rather curiously.

WE are told that the efficiency of the parallel system with one car and 40 cars is 80 and 9 per cent. respectively, but that the series plan under like conditions as to the number of cars, shows 67 and 99 per cent efficiency. What, one might well ask, would the latter work out with 50 cars in operation? As, however, this statement and others to which exception might be taken are evidently American calculations, we pass them by without further comment. We hope shortly to be able to still further investigate this interesting method of propelling tramcars and in the meantime we heartily wish the promoters the success which their efforts have deserved. Mr. Manville should be specially commended, for his work has been no sinecure, as we all know that in matters of this kind the electrical arrangements are as often at fault as those of a purely mechanical nature. The particulars which we publish on another page, combined with a reference to that number of the REVIEW previously mentioned, will give our readers a very complete idea of the series electrical traction system.

WE think upon further reflection, that Professor George Forbes has unnecessarily alarmed the users of lead covered conductors by stating his conviction that such leads cannot be reckoned to last more than three years. We have had shown to us a specimen of lead covered wire which was laid underground 35 years ago and which still appears to be in excellent condition. On the other hand, we know of an instance in which, after a few years, the lead covering of an underground conductor insulated with cotton steeped in melted paraffin wax, was completely eaten away. The preservation or destruction of a lead covered wire depends mainly upon the soil in which it is laid and, when in localities where the earth affects the metal, upon the precautions adopted to keep it away from its deleterious surroundings. If embedded in peat, we believe lead is practically imperishable.

JOURNALISM in America, like everything else in that go-head part of the globe, is much afflicted with a tendency to boastfulness. True there is, in many cases, something to boast about, but the way in which many of our otherwise estimable contemporaries in the electrical field talk about themselves, their energy, progress, and enterprise, makes us smile, sadly smile, to see such excellent, well-conducted journals depart so far from the paths of modesty. The copies latest to hand of two well-known American electrical journals, one from New York the other from Chicago, run each other very close in a bragging competition. We rather fancy Chicago scores in this particular competition, if not in the journalistic one.

A SYNTHETIC STUDY OF DYNAMO MACHINES.

(*Continued from page* 239.)

VI.—ARMATURES IN PRACTICE.

IN the machines of Siemens and Ferranti, we have another alternator without iron in its armature. These machines differ only in their details; electrically they are exactly similar, and the same description applies to both. The field is constituted by groups of lines passing between magnets of alternate polarity arranged in a circle, as shown in fig. 49 (page 629, Vol. XXIII.). On two flat ring frames, lying parallel to each other, are projecting cores, on which the magnetising coils are wound. The cores on opposite rings face each other, and the current flows in the magnetising coils so as to produce the polarity marked in the fig. In machines of this class the field is, of course, fixed, and the trapezoidal coils constituting the armature move in the space left between the opposite polar faces. A number of the armature coils, A, B, C, D, E, are shown in fig. 81, the poles alternately of N and S polarity being marked N_1, S_1, N_2, S_2, N_3, S_3. Here there are as many field poles as there are armature coils, while in the alternator described a fortnight ago, the field poles were equal to half the number of coils. The width of the coils is equal to the pitch of the magnets, while the width of the poles is equal to about half the pitch. The armature coils may be coupled all in series, or in groups of several in series, as the case may be, the direction of coupling being shown diagrammatically in fig. 82. Consider the induction in coil A (fig. 82) while it moves through one complete cycle, that is, from the time it leaves its position opposite N_1 till it takes a position opposite N_2. Call N, as before, the number of lines of force in each group, and note that if the side, *a*, *b*, of the coil is cutting lines of force from a north pole, while *c*, *d*, is cutting lines from a south pole, the effects of the two are added, for though the induction in the two sides is in the opposite direction, regarding the sides as components of the coil it is in the same direction. To reach position S_1, *i.e.*, in half a cycle, *a*, *b*, cuts all the lines of force in group N_1, and *c*, *d*, cuts all the lines of force in group S_1. There is then a reversal. In the next half cycle, *a*, *b*, cuts all the lines in group S_1, and *c*, *d*, all those in N_2. There are thus 4 N lines cut per cycle, and if there are n cycles per second, the E.M.F. in volts per coil is

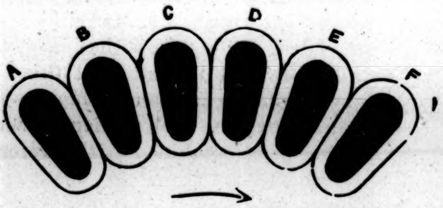

FIG. 81.

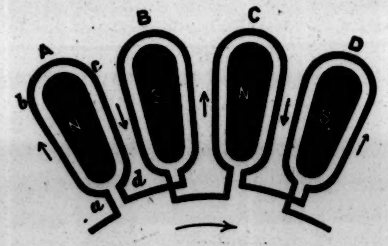

FIG. 82.

$$E_{\text{average}} = \frac{4\,N\,n\,c}{10^8}.$$

In this machine the number of cycles per second is equal to the product of *s*, the revolutions per second and $\frac{p}{2}$ where *p* is the number of poles. We thus get for the average E.M.F. per coil,

$$E_{\text{average}} = \frac{2\,N\,p\,s\,c}{10^8}.$$

It is unnecessary to draw the curves of induction for these machines, as this would be to a great extent a repetition of the last article. Suffice it to say that where we have the groups of lines alternating in direction, and equal to the number of armature coils, the curve for each individual coil, provided there is the same number of lines in each group, is symmetrical, and the induction curve, as modified by the spreading of the field, the shape of the coil and the width of the conductors composing it often resembles closely the curve of sines which has been frequently referred to. Its actual shape must, however, depend upon the manner in which the different things above mentioned are related to each other. Since the induction in each coil is symmetrical, the E.M.F. curve for any number of the coils coupled in series is that given by multiplying the ordinates of the curve for a single coil by the number so coupled. To obtain the E.M.F. for the whole machine, the above expression must be multiplied by the number of coils in series, and if for the number of revolutions per second we substitute in the equation the revolutions per minute, the denominator must be multiplied by 60. The ends of the armature coils after coupling in a manner to give the desired E.M.F. are led to rings insulated from, and concentric with the shaft, on which press the rubbers or brushes leading to the external circuit.

It might be interesting to compare the merits of these two types of alternators. In making a comparison the efficiency and the expense of construction are the chief things to be considered, the ratio of weight to output being unimportant except for the reason that additional weight means increased price. Let us imagine we have two alternators, one designed by Mordey and one by Ferranti. The armatures will be of the same diameter and will have the same number of coils with the same number of convolutions. The number of revolutions per minute shall in both be similar—What will be their respective outputs? It will be seen that the expression for the E.M.F. of the two types is the same $= \frac{2\,N\,p\,s\,c}{10^8}$, but in the Mordey machine there are only half the poles that there are in the Ferranti for the same number of armature coils, and at first sight we might suppose that the former design could only give half the E.M.F., and consequently half the output of the latter. But there are circumstances which modify this conclusion. In the Mordey alternator there is no waste field or leakage of lines between adjacent magnet cores, while in the Ferranti machine, on the other hand, the lines passing between adjacent cores may be 50 per cent. of the total lines induced. These lines constitute a waste field as they do not add in any way to the E.M.F. of the machine. The area of the polar faces being in both cases the same, it follows from this that in the Mordey type N, the number of lines from each pole finding their way through the armature coils is about twice that in the Ferranti type, the total lines passing through the armature being therefore the same in both machines. These considerations lead to the interesting result that the former machine will generate about the same E.M.F. as the latter, notwithstanding the fact that it has only half the number of poles of similar area.

There is a considerable saving effected in the magnetising power by employing a single sub-divided magnetic circuit (fig. 46) as in Mordey's machine instead of a number of shorter magnetic circuits (fig. 49) as in Ferranti's. When speaking of the Ferranti type of field, see fig. 49, Vol. XXIII., we observed that the magnetising coils on a pair of opposite poles had to provide the induction through the air gap, through their respective cores and through a length in each of the ring frames equal to the distance between two adjacent cores. In the Mordey alternator the one magnetising coil provides the induction simultaneously for all the magnet projections and intervening air gaps. Comparing an eight-pole Mordey machine with a 16-pole Ferranti, the circumference of the magnet core in the former to the added peripheries of the magnet cores in the latter is about as 1 to 5. There will not be so many ampère-turns required on each pair of poles in the 16-pole machine as on the single coil, for although the air part of the magnetic circuit is of the same length the iron part is much shorter. But at the lowest computation the product of the length of wire and current required for exciting the Ferranti machine will be about three times that required for a Mordey machine of the same size, and this means that a greatly increased amount of copper will be required on the magnets.

We have found that both machines give the same output, which is true on our assumption of the useful field being only 50 per cent. of the total field. If the useful field is greater than this, we shall of course get an increased output to compensate for the increased weight of copper on the magnets. The useful percentage may be greater than that stated, the figure here given being obtained from a small machine not of the latest design. The power spent in exciting the field of a Ferranti machine of 150 horse-power, of which the particulars have recently been published, amounts to 2·3 per cent. of the total output, while in a Mordey machine of 60 horse-power only 1·25 per cent. of the total output is spent in magnetising in the field coil.

There is no doubt that the Mordey machine is of simpler and less expensive construction than the Ferranti, for sizes of the former made up to the present. But, on the other hand, it is doubtful whether Mordey's design would show a proportionate difference in price when applied to the construction of very large slow-speed machines, such as are now being made to Ferranti's design.

[ERRATA.—On page 237 half way down the right hand column read *multiply the denominator by* 60 instead of divide the denominator by 60.]

(*To be continued.*)

DIFFUSION IN DOUBLE FLUID BATTERIES.

NO one who has had to deal with double fluid batteries, especially those employed for telegraphic purposes, can have failed to notice the serious inconvenience caused by the rapid diffusion which takes place between the two liquids separated by the porous division (usually a round or flat porous pot). The harder the substance of the dividing partition, that is to say, the less its porosity, the less is the rate at which diffusion takes place; but, on the other hand, the greater is the electrical resistance of the same. Low resistance then is practically synonymous with open porosity; consequently in low resistance double fluid batteries where the two liquids are kept separated by a porous division, rapid diffusion takes place with an attendant local decomposition of the liquids and consequent waste and deterioration without useful work being done. In the case of Daniell batteries the effects of diffusion are very marked in the blackening of the zinc plates, the wasting of the copper sulphate, and the general fouling of the cells.

Although the fact of the diffusion taking place has, of course, been known ever since double fluid batteries were invented, no serious attempts, as far as we are aware, have been made till quite recently to effect a remedy for the evil. Messrs. E. L. Mayer, and H. Liepmann have, however, taken the matter in hand and with the most remarkable results. The process consists in modifying the pores of the porous by a chemical treatment, with the result that whilst the electrical resistance* of the cells in which the treated porous pots are employed is not greatly increased, the rate at which diffusion between the separated liquids takes place is most notably diminished.

That the process is a most effectual one will be seen from the following tests which were made by Mr. H. R. Kempe with a number of circular porous pots of the type employed in the Fuller bichromate battery.

The system of tests consisted in taking a number of the porous pots and then treating a portion of them by the process in various manners and to different degrees. The pots were then placed in outer jars filled with pure water and a number of them charged with an acidulated solution of bichromate of potash, and the remainder with a solution of sulphate of copper. Chemical analyses were then made from day to day of the solutions in the outer jars, with the results shown in the following report:—

The Laboratory, 11, Billiter Square, E.C.,
London, *March 5th*, 1889.

Report on Battery Solutions from Diffusion Experiments.

I have on various days during the latter part of February received a number of solutions of sulphate of copper and bichromate of potash from Mr. E. L. Mayer, with the request to estimate on them the percentage of the above-mentioned substances. I give below a tabulated statement of the results obtained.

(1) *Copper Solutions.*—The "original solution" was found to contain 3·54 per cent. of copper corresponding to 13·93 per cent. crystallised sulphate.

Calling the quantity of copper in the original solution 100, the percentage of copper in the various diffusion liquors was as under:—

Sample marked.	20/2	21/2	22/2	25/2
Not	·356	1·808	2·73	6.00
Not	·401	1·84	3·21	7·30
‖ 2 ‖	faint trace	trace	·46	1·29
‖ 9 ‖	none	faint trace	·21	·38
‖ 8 ‖	none	none	none	faint trace
| 2 |	·29	1·85	2·55	6·59
| 3 |	·76	2·49	3·90	8·17
‖ 4 ‖	trace	·22	·55	1·55
‖ 6	trace	·22	·56	1·24
| B |	·79	2·55	3·49	7·21
| C |	·54	2·20	2·99	6·33
‖ 11 ‖	trace	·22	·54	1·21
‖ 12 ‖	trace	·25	·66	1·42

(2) *Bichromate Solutions.*—The original solution contains 11·9 per cent. of bichromate.

Calling the quantity of bichromate in the original solution 100, that in the various diffusion fluids was found to be:—

Sample marked.	20/2	21/2	22/2	25/2
Not	3·66	8·17	11·77	20·80
‖ 1 ‖	·50	1·55	2·82	5·12
‖ 7 ‖	faint trace	·12	·16	·64
| 1 |	3·79	8·61	14·06	21·48
‖ 3 ‖	·95	2·19	4·04	7·19
‖ 5 ‖	·30	1·71	3·31	7·48
| A |	4·14	8·13	11·50	18·36
‖ 10 ‖	1·55	3·49	5·79	10·90

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* By resistance is here meant the resistance of the liquid in the pores, not the conducting power of any solid material which may fill the pores up.—EDS. ELEC. REV.

It will be seen that in the case of each sample marked with a double line, the diffusion was greatly smaller than in the samples not so marked.

OTTO HEHNER, *Public Analyst.*

At the conclusion of the diffusion experiments the pots were made up in ordinary Fuller bichromate and Daniell batteries, and the resistances of the latter were carefully measured.

A summary of the results are given in the following tables.:—

TABLE I.

Showing the rate of diffusion through various porous pots, treated and not treated, between a solution of sulphate of copper and pure water.

The copper solution contained 3·54 per cent of copper, = 13·93 per cent. of crystallised sulphate of copper.

Porous pots.	Marked.	Resist.	Original copper solution = 100. Pure water contained copper after			
		Ohms.	24 hours.	48 hours.	72 hrs.	144 hours.
Not treated...	...	3·3	0·36	1·81	2·73	6·00
Not treated...	...	2·3	0·40	1·84	3·21	7·30
Treated	‖ 2 ‖	2·6	faint trace	trace	0·46	1·29
Treated	‖ 9 ‖	5·6	none	faint tr.	0·21	0·38
Treated	‖ 8 ‖	3·8	none	noue	none	faint tr.
Not treated...	| 2 |	2 9	0·29	1·85	2·55	6·59
Not treated...	| 3 |	2·3	0·76	2·49	3·90	8·17
Treated	‖ 4 ‖	2·5	trace	0·22	0·55	1·55
Treated	‖ 6 ‖	2·6	trace	0·22	0·56	1·24
Not treated...	| B |	2·6	0·79	2·55	3·49	7·21
Not treated...	| C |	2·9	0·54	2·20	2·99	6·33
Treated	‖ 11 ‖	3·0	trace	0·22	0·54	1·21
Treated	‖ 12 ‖	2·6	trace	0·25	0·66	1·42

TABLE II.

Showing the rate of diffusion through various porous pots, treated and not treated, between a solution of bichromate of potassium and sulphuric acid, and pure water.

Original bichromate solution contained 11·9 per cent. bichromate.

Porous pots.	Marked.	Resist.	Original bichromate solution = 100. Pure water contained bichromate after			
		Ohms.	24 hours.	48 hours.	72 hrs.	144 hours.
Not treated...	...	2·6	3·66	8·17	11·77	20·80
Treated	‖ 1 ‖	2·8	0·50	1·55	2·83	5·12
Treated	‖ 7 ‖	2·9	faint trace	0·12	0·16	0·64
Not treated...	| 1 |	0·9	3·79	8·61	14·06	21·48
Treated	‖ 3 ‖	1·1	0·95	2·19	4·04	7·19
Treated	‖ 5 ‖	2·3	0·30	1·71	3 31	7·48
Not treated...	| A |	0·8	4·14	8·13	11·50	18·36
Treated	‖ 10 ‖	1·2	1·55	3·49	5·79	10·90

The results as regards the bichromate cells are not uniform, as the treatments to which the various pots were subjected were not the same, but they are in all cases most decidedly in favour of the treated pots. In the case of the Daniell cells the results are very marked, the diffusion being for porous pots of nearly equal resistance, but some treated and others untreated, in the case of the treated porous pots but $\frac{1}{6}$th of that in the untreated ones

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ON ELECTROLYSIS.

By MM. VIOLLE and CHASSAGNY.

THE decomposition of water by means of an energetic current is accompanied by luminous and thermic phenomena which were pointed out 40 years ago by MM. Fizeau and Foucault, and which have since been studied by many physicists. The use of a Gramme machine supplying 40 ampères with an electromotive force of 110 volts has permitted us to obtain these phenomena with ease, to observe them under well-defined conditions and to observe some novel circumstances.

Into water containing $\frac{1}{10}$th of sulphuric acid, a platinum wire of $4\frac{1}{2}$ millimetres in diameter was deeply immersed. The negative electrode consisted of a platinum wire of 1·6 millimetres in diameter, which was very slowly immersed in the cold liquid.

If the difference of potential at the extremities of the voltameter is greater than 32 volts, we observe around the negative wire a luminous covering, separate from the liquid, and in which the disengagement of hydrogen is entirely effected. It presents a very strong resistance to the passage of the current, which diminishes slowly in proportion as the coating expands on penetrating into the liquid along with the wire, and which falls abruptly at the point where the coating disappears to give place to the ordinary liberation of bubbles. The following table indicates the maximum length, *l*, which this coating can reach for a given electromotive force, E, in a cold liquid. I is the indication of a Deprez-Carpentier ampèremeter introduced into the circuit :—

l	E	I	E I	
Cm.	Volts.	Ampères.	Observed.	Calculated.
1	35	0·9	32	32
2	39·3	1·6	63	64
3	41·5	2·4	99	96
4	42·8	3·1	132	128
5	44	3·7	163	160
6	44·8	4·3	192	192
7	45·5	4·8	218	224
8	46	...	...	...

The quantities of electric energy given out in the voltameter are distinctly proportional to the maximum lengths of the coating which they produce.

The light appearing on the electrode is discontinuous. There are at first only some brilliant orange points at the extremity of the wire, and then a fringe of a violet colour extends along all the immersed portion.

This portion becomes very hot, and the heat contributes much to the maintenance of the coating. If we suppress the current the coating does not at once disappear, and there is a hissing sound when the liquid comes in contact with the metal. The passage of the coating to the bubbles when the electrode is gradually immersed and reaches a certain depth is attended with a kind of explosion. On the other hand, with a potential below 32 volts we may produce the coating along the negative wire previously heated; but then the phenomenon is transitory, and soon an escape in the form of bubbles takes place through the liquid, where it comes in contact with the cooled wire.

When the coating is established for a certain length, if we gradually increase the difference of potential between the two electrodes the thermic or luminous phenomena become more intense. The discharges which illuminate the coating become more numerous or more vivid, the escape of gas increases, the liquid rises around the electrode, the coating widens and is broken up with light and noise into large compressed bubbles. The immersed portion of the electrode becomes red hot, and even melts. With an electromotive force of 80—100 volts it is easy to fuse platinum wire of 1·6 millimetres in diameter, immersed to a depth of 2—4 centimetres whilst the part of the wire outside the liquid is scarcely hot.

With a great difference of potential it is difficult to produce, and still more difficult to maintain, the coating, which on the least agitation is resolved into crackling bubbles.

This violent form of electrolysis is accompanied by a superficial disaggregation of the negative electrode, the liquid soon becomes charged with a very heavy black powder, consisting essentially of a platinum hydride, which decomposes in a vacuum above 760° F., and answers to the formula Pt_2H.

We have occupied ourselves hitherto only with the phenomena at the negative pole. A coating may also be observed at the positive pole. For this purpose it is sufficient to invert the conditions of the experiment, attaching to the negative pole the wire of 4½ millimetres, deeply immersed in the same acidulated water, and to immerse gradually the wire of 1·6 millimetres attached to the positive pole. There is greater difficulty in obtaining the coating which is not distinctly formed with less than 50 volts, but which is remarkably persistent; it is, however, much less luminous.

If the coating is first produced upon the thick wire, the fine wire being plunged to 2—3 centimetres, then in proportion as the thick wire is immersed more deeply the coating is elongated up to the point where it disappears abruptly. But then the intensity of the current augments, and the other electrode may become sufficiently heated to become covered with a luminous coating or with crackling bubbles.

Similar phenomena, but less intense, may be obtained in water acidified with phosphoric acid. The normal decomposition is less easily interfered with, as has been already indicated by M. Mascart.—*Comptes Rendus.*

nearly 3 tons of copper per mile—and assuming that 400 H.P. were required to be transmitted to a point midway on a line five miles in length, the initial power required to be delivered to the terminals of the conductors to realise the 400 H.P. in useful work at the midway point would be upwards of 2,500 H.P. Now, in series running, allowing the same difference of potential at the terminals of each motor—*i.e.*, 200 volts—405 H.P. only would be required to deliver 400 H.P. at the midway point along a line of the same length. Although it is possible in parallel running to expend still more capital in conductors—or to use a higher voltage increasing the danger of short circuits—the difference in efficiency between the parallel and series systems must always be well marked.

It has hitherto been considered that there were serious mechanical difficulties in the application of the series system of distribution, but these, it is claimed by the Series Traction Syndicate, have been successfully overcome.

In order to make this system suitable for adoption in ordinary roads and streets, the first point to be considered in designing the mechanical details was the construction of such a conduit as would cause the least possible interference with the surface of the roadway, and would be of sufficient structural strength to provide for the heavy traffic of our large towns. In order to avoid a greater interference with the surface of the road than is common to ordinary horse tramways, it was decided in the first instance that the conduit should be laid directly under one of the track rails, and not, as in the case of cable tramways, centrally to the track. The further consideration of interfering as little as possible with the water and gas mains existing below the surface of the roads required that this conduit should be kept to the smallest possible dimensions, consistent with practicable working.

The tube, as constructed at Gravesend, is 8 inches in width, the bottom being 13 inches below the surface of the road. The slot through which contact is made between the underground conductor and the car-motor is formed by leaving a space ⅛th inch between two bull-headed rails, somewhat similar to the ordinary Vignole's

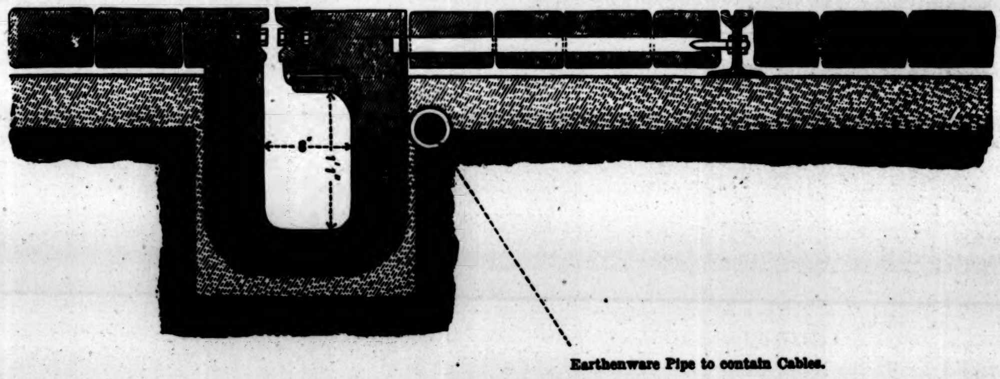

FIG. 1.—GENERAL CROSS-SECTION.

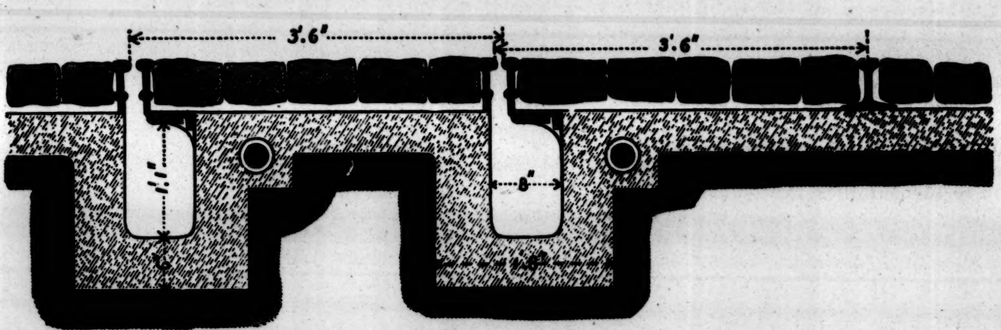

FIG. 2.—CROSS-SECTION OF INTERLACING LINE.

SERIES ELECTRICAL TRACTION FOR TRAMLINES.

THE tramway line of the Series Electrical Traction Syndicate, Limited, has just been completed and opened at Northfleet.

It has been built to show the practicability of running electrical tramcars in series with each other.

As yet the running of electrical tramways by underground conductors has not been attempted at a much higher potential than 200 volts; a much higher voltage than this would involve great chances of breakdown of insulation, due to the necessarily near proximity of conductors of opposite potential. As an example of the loss of power that would take place with tramcars driven by electricity of this potential (200 volts) on a large scale, the following startling figures compiled by the syndicate will suffice:—Starting with a conductor of very large area, say with an electrical resistance of ·15 ohms per mile—which represents a weight of railway rail, these being 4½ inches in depth, with upper flanges 1¾ inches wide. The outer of these rails serves as the tread for the tramway wheel, the inner corresponding to the guard-lip of an ordinary tramway rail. These rails are secured through their webs to cast iron chairs or yokes, at intervals of about 4 feet, the yokes being of such section as to leave a clear space below the bottom flange of the rail of 13 inches by 8 inches. The walls of the conduit between the yokes are formed of Portland cement concrete 6 inches thick. The rails are laid in lengths of 21 feet; the yokes on either side of the joints being placed 1 foot 5 inches apart, centre to centre, and a chamber is formed where these joints occur, covered on the inner side of the rail by a small hatch, 1 foot 4½ inches by 8½ inches, recessed on the surface and filled with wood-paving blocks. These chambers serve for the purpose of access to the "spring jacks," or contact points, to which reference will be made further on, and also admit of the removal of any dirt which may possibly accumulate in the tube, and, further, gives facility for tightening up the fish-plates at the rail joints. The corresponding tramway rail is of the ordinary girder type, the gauge being maintained by means of tie-bars attached to the girder rails and the cast iron yokes, and require no further description. Fig. 1 shows the general cross-section of the roadway.

The narrowness of a portion of the road on Northfleet Hill necessitated the construction of a portion of interlacing or "double-single" line. In this instance three rails are laid, two of them being conduit rails, and the third an ordinary girder rail, a cross-section of which is shown in fig. 2. The car, travelling in either direction, uses the central rail, which in one direction serves as a conduit, but in the other direction takes the place of the ordinary girder rail. At the turnouts the junction of the conduits underneath the road necessitates the construction of somewhat special points and crossings. The points are provided with movable tongues set so as to automatically direct the traffic to the left-hand side of the road, and in order to avoid risk attendant on having a long unsupported tongue forming the roof of the conduits at their junction, a special tumbler has been designed, so formed that it provides a support for the point of the tongue under ordinary conditions, but during the passage of a car it is deflected out of position so as to allow a full clearance for the current collector or "arrow." Where it is necessary, as for instance, at the terminal fork at the Northfleet Station end of the line, to provide a means by which the cars can be caused to take either track, a claw is pivoted on to the tumbler, which can, by means of a lever, be made to engage with the under surface of the tongue, and thus draw it into the required position.

Along each side of the track, buried in the concrete, is an earthenware tube, 3 inches in diameter, the ends of which protrude into the cavity formed under the conduit hatches where they are open for access. Into these tubes are drawn lengths of about 21 feet of Henley's highly insulated ozokerited rubber cable, of an insulation resistance of 7,500 megohms per mile, and also the unbroken return cable from the extreme end of the line, it being considered essential in this system that the earth should form no part of the circuit.

These short lengths of highly insulated cable are the only conductors between the "spring jacks," the conduit between being only for the passage of the arrow, and, therefore, otherwise empty. In each conduit chamber is placed a "spring jack," consisting of a pair of glazed earthenware blocks, 14 inches × 3 inches × 4 inches, supported on brackets cast on to the joint yokes, the blocks facing each other on opposite sides of the tube. To each block is attached, by means of a double spiral spring, a gun metal casting, curved at the ends but flat in the centre. The springs are of sufficient strength to press the two castings together with a force of 6 lbs. The "spring jack" is shown in fig. 3. Under the car, and for its full length is the collector, or "arrow," which consists of two thicknesses of India-rubber belting, each having a broad brass strip rivetted to it for nearly its entire length. The nose of the arrow at each end is shod with wrought iron brought to a knife edge, so as to easily force its way in between the two faces of the "spring jack." The maximum thickness of the arrow is 1 inch, which is consequently the extent to which the gunmetal cheeks are separated.

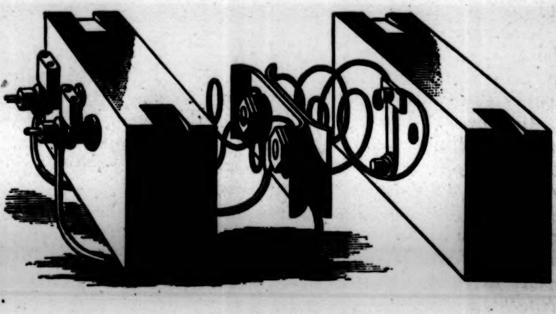

FIG. 3.

The conductor on each side of the arrow is lapped round one end, and an insulated space is left slightly greater than the surface of contact of the "spring jack" near the extreme ends on opposite side, as will be seen by the diagram, fig. 4, where 1 and 2 represent the conductors, 3 the insulated gaps, and B the "spring jack" cheeks. With this arrangement it will be seen that in the passage of the arrow from one "spring jack" to the other, one-half of the "spring jack" which is being entered, and one-half of that which is being left, together with the length of cable between them (4) is completely cut out of circuit, the current being, meanwhile, supplied to the motor from the remaining opposite halves of the "spring jack." It will be readily seen from this that at no moment is the current cut off from the motor, or at no moment is the motor short-circuited; in fact, the ammeter carried on each car shows the constant value of the current without any variation. Diagram, fig. 5, shows the arrangement of the entire circuit with an arrow passing through the "spring jacks." The "spring jacks" are arranged to be taken out or replaced in the conduit in the course of a few minutes. Short-circuiting pieces are provided to enable the continuity of the circuit to be maintained should a "spring jack" require to be replaced without interrupting the service during the operation, the car easily running by its own momentum through the distance of 21 feet, in which it would receive no current. These "spring jacks" are very simple pieces of apparatus of small cost, and the contact they make by their surfaces being pressed together is excellent, the resistance of the line being but very little higher than that calculated from the direct resistance of the insulated cables themselves.

The cars used at Gravesend are supplied by the Falcon Engine and Car Works, Loughborough. The motors are run at 400 revolutions per minute, delivering at this speed, when the field magnets are fully excited, 15 horse-power on the brake. They were made by Messrs. Elwell-Parker, and the peculiarity of their shape is owing to the fact that they had to be made very narrow so as to fit under a car running on a 3 feet 6 inch gauge. The front of the motor is supported by two bearings on the driving shaft of the car, the rear being suspended by a spiral spring from the car body. A double helical pinion on the motor shaft drives directly a spur wheel on the car shaft, in the ratio of 1 to 4½.

The regulation of the motor is attained by massively-constructed switches mounted on each platform. One of these switches reverses the connections of the field so as to reverse the direction of the car; the other regulates the resistance of a shunt to the fields, so as to weaken or strengthen it, in proportion to the power required.

One of the cars is lighted electrically by means of low resistance lamps of the Bernstein make. Three accumulator cells, each of 31 plates of the tramway type of the Electrical Power Storage Company, are inserted in the main circuit, and five lamps of 10 ampères each, and 6·5 volts are run in parallel off the accumutators. The accumulators themselves, however, are not discharged; they only serve as potential reducers, the whole of the main current going through the lamps. Should one of the lamps break, the remainder are slightly more brightly incandesced, and the current due to the broken lamp passes through the accumulator. A two-way switch enables the accumulator to be taken in or out of the main circuit, and the accumulators are large enough to run all the lamps without assistance from the main current should it be requisite.

The "arrow" is under one side of the car, and is supported at distances of 5 feet 7 inches on cast iron bearing blocks, sliding along the surface of the rail. These blocks are connected with iron tie bars, which take all strain off the Indiarubber belt, the whole gear being propelled by the car. It being requisite that current of perfectly constant value should be generated to work the system, the syndicate selected one of Messrs. Statter and Co.'s constant current machines. This machine fulfils the rather arduous conditions which are imposed upon it, perfectly, the E.M.F. being continually varied from a few volts to upwards of 400, the current always remaining constant at 50 ampères.

FIG. 4.

FIG. 5.

The generator is driven by a Robey Compound underneath type engine of 10 H.P., nom., with locomotive boiler over it.

It will be seen that, in addition to the economy of running obtained by the Series system, the manner in which the details are carried out have many important advantages. By the use of highly-insulated cables for the greater portion of the length of the line, and where the "spring jacks" occur, by having but very small bare surfaces of conductor exposed to the insulating blocks, the possibilities of high insulation are obtained. The divided conductor being in very short lengths a section of it can be renewed in a very short time without interfering with the traffic of the line. The conduit being perfectly empty, excepting at the "spring jack" chambers, is easily cleaned, and need never require taking up. An incipient fault in the line is easily detected and localised by the car-drivers through the ammeters. The form of the conduit is such that the "spring jacks" are not directly beneath, the slot being thus protected from road *débris*, in addition to being placed out of danger of interference from the surface, so that even should an "earth" exist, it is impossible that a shock should be received through them.

The "spring jacks," switchgear, lighting, and sundry apparatus have been supplied by the United Electrical Engineering Company, Limited. The whole of the road work and mechanical details were designed by Mr. Joseph Kincaid, M.Inst.C.E., the Company's Consulting Engineer, and the construction was executed for him, under the personal supervision of Mr. J. E. Waller, A.M.Inst.C.E., by Messrs. Dick, Kerr and Co. All the works in connection with the details of the electrical portion of the undertaking were arranged by, and carried out under the direct supervision of the Company's Electrical Engineer, Mr. E. Manville.

ELECTRO-THERAPY OF FACIAL PARALYSIS.

By M. DANION, in the *Journal de Médicine de Paris.*

I HAVE desired to profit by fortuitous circumstances which have permitted me to group five individuals attacked with peripheric facial paralysis, and who, except one, are still treated at this moment by electricity, in order to present them to you. The observations of these five persons have appeared interesting to me.

The first observation refers to a person (Madame Galopin) who eight years since was attacked by complete facial paralysis on the left side. She was treated from the outset by very strong faradic currents. At the commencement of July, 1888, she was treated at the Saltpêtrière by the bath and the electric *souffle*, without any result. She came to my dispensary on August, and was treated galvanically by currents of from 4 to 6 milliampères. The pain, which was the greatest pre-occupation of the invalid, disappeared after the third sitting, and has never reappeared since that time. The invalid underwent the same treatment twice a week, and improved progressively. The contractions of the frontal and the levator of the eyelid are still incomplete; but the remainder of the face contracts well enough.

The second observation concerns Joseph Heck, aged 30, a waiter. In this instance rapid strides were made after a chill at the beginning of July. Intense cephalalgy, complete paralysis of the upper and lower face in the space of two or three days. Consultation 15 days after at the Hôtel Dieu; sent thence to the Saltpêtrière. Three static sittings per week; result, *nil*. Came to my dispensary on September 2nd; complete paralysis of the whole of the left side of the face, the whole of that side being as immovable as if it were made of stone. There existed an almost absolute reaction of degeneration. September 3rd.—Weak galvanisation of the trunk of the facial with the anode, the cathode remaining applied to the nape 5 to 7 m.a., from 5 to 10 minutes. September 7th to 10th.—Same treatment;

slight movements of the levator of the lip. September 14th to 17th.—Slight movements of the orbicular and of the levator of the nose. October 4th.—Large wrinkles began to form in front, the other muscles contracting well. November.—The contractions, except in front, were almost normal; the invalid, who had returned to his work, only came rarely up till last January, so that the cure made little progress.

Third observation.—M. Kuffenheim, aged 52. Complete facial paralysis began in one night about the commencement of July, 1888, after a chill in a building in course of construction. Treated at the Salpêtrière for 3½ months without result. Contraction of the nasolabial and zygomatics. December 3rd, 10th and 24th.—Three sittings with the same treatment. The improvement was apparent. The forehead moved more easily, the side was freer, the invalid ate and spoke better. December 21st.—The forehead moved almost to its greatest extent, the lower facial showing less progress. January.—The contraction was much less accentuated, the mouth less deviated, and, generally, there was a remarkable improvement.

Fourth observation.—Seguin, gendarme, facial paralysis of the left side. Commencement on February 12th, 1888, suddenly and without known cause. Treated at the Val de Grâce with strong continuous currents and with iodide of potassium. He remained there 4½ months, with a consecutive mediocre improvement. From the 24th of July he was treated at the Salpêtrière without any change. This patient consulted me on December 3rd. General facial paralysis with contraction of the lower muscles. Gustatory perversion, indicating that the trunk of the facial was injured. December and January.—Five galvanic sittings with the same treatment. The contraction had improved, the frontal contracting a little better.

Fifth observation.—Mdlle. Vasselin. Slight facial paralysis on the right side. Commencement sudden without known cause, the paralysis of the lower facial being especially accentuated. Same treatment as above; very marked improvement after two sittings, complete one after the eighth.

All the preceding observations show, as well as many others which I could cite, contrary to the opinion which has been admitted not only by doctors, strangers to electrotherapy, but also by electro-therapeutists of merit, such as de Watteville and Ricardo-Jorge, that electricity has an indisputable effect in cases of facial paralysis, and I may add, whatever the age, for I have successfully tended facial paralysis dating from a nine years' standing and another of eleven years. With one of the five patients mentioned, the complicated contractine paralysis was of eight years' standing. This fact had, moreover, been abundantly proved by Duchenne (of Boulogne), and one is justified in expressing astonishment at being contradicted by electro-therapeutists. It must be admitted that chance has made them happen upon cases quite incurable, or that their treatment has been badly directed.

The first four of these observations prove, without discussion, that treatment such has been instituted at the Salpêtrière, is absolutely useless, and one may add that it is fortunate that the employment of the static mode has been limited to the use made of it. It is probably, also, because experience demonstrates that the electrostatic sparks have a fatal irritating action in cases of facial paralysis, which they predispose to contractions. The absence of all other therapeutics leads one to conclude, on the other hand, that the employment of other methods is considered as completely useless, or that it was so for the patients of whom I have spoken, which doubles the value of the results obtained, and also dissipates doubts. The patient in the fifth observation was cured absolutely and very quickly, but the contractility was nearly indemnified, and this one only confirmed the rule.

As to the patient who is the object of the second observation, his affection was serious, and yet it improved with great rapidity under the influence of very weak continuous currents. The contraction of Madame Galopin also gave way very quickly to the same treatment, while, on the other hand, the paralysed muscles resumed their contractility. This patient showed besides the consequences which a badly directed treatment may have, for the history of the affection does not allow of a doubt that the brutal faradisation which was carried out caused the contraction and pains which tormented her during her illness. It was also to the application of weak continuous currents that the patient showed such notable improvement in a small number of sittings, and yet the affection dated from five months back when the treatment was begun. As to the patient in the fourth observation, of whom the great zygomatic especially is still strongly contracted, he was treated at the Val de Grâce by violent continuous currents, and in reconciling this observation with another that is personal to me, and in which continuous currents (which, however, did not exceed 12 to 15 milliampères) appear to be responsible for an analogous result, their use, it seems to me, should be proscribed from the therapeutics of facial paralysis, especially when their application is made peripherically and the affection is yet recent.

It seems, therefore, in all the methods that an action even moderately energetic must be banished from every method of treatment, and I believe the moment has come to remember that Duchenne (of Boulogne), who made an exclusive use of the faradic method, insisted on the dangers of too strong currents, which, he said, provoked contractions. He was, moreover, convinced that continuous currents produced the same results. The danger of an energetic treatment seems directly connected with the superficial anatomical disposition of the terminal branches of the facial, and there is occasion, in my opinion, to ask oneself if it be not electricity which must be made responsible, to a certain extent, for the contractions which frequently complicate the termination of paralysis. Out of the five patients presented to you, and all five of whom have been treated electrically, three were attacked with contractions; I might add to them another, one of two I am now attending, and who has seen his paralysis complicated with contractions. There are then, out of a total of seven patients, four of them attacked with this complication; and if the patient mentioned in my fifth observation, who had only a slight attack, be eliminated, there remain two-thirds who have not escaped this complication.

The question would have been judged immediately if it had been observed previously; but Duchenne (of Boulogne) was the first who noticed it, and he faradised his patients. I may hasten to add, however, that if, without doubt, the contractions may be the consequence not only to the face, but also to the other regions, of a badly directed electrical treatment, it is rational to admit that they may be a natural complication of this species of affection, a complication which would take its point of departure in an irritative (?) state of the nerve, however vague the word "irritative" may be. If one will remember that continuous currents, weak or moderate (according to the muscles operated upon), are, in some degree, the specific treatment of contractions; if one will also remark, on another side, the weak continuous currents have given excellent results in the treatment of paralysed persons to whom they have been applied, and seem even to have given better results than any other method of treatment, he will arrive at the conclusion that the application of weak continuous currents, varying between 4 to 5 m.a., and never exceeding 6 to 7 or 8 m.a., applied stabilely and weakly on the trunk and branches of the facial nerve, constitutes the best method of treatment of facial paralysis of peripheric origin. It is a treatment which has, in every case, a considerable advantage over the faradic treatment. This is, that it is extremely easy of application, and that it is a preventive of contractions.

Is this saying that the faradic treatment cannot give good results? By no means; and Duchenne has superabundantly demonstrated the contrary; but Duchenne was a master and an artist at the same time. He had a marvellous knowledge of the human physiognomy, and knew how to fashion a face while using all the degrees of faradaic intensity. I believe sincerely that very few doctors, even among the electrotherapeutists, could do what Duchenne did, but all could apply the method which I extol. From another point of view, is this to say that strong intensities, as well as the resources of faradisation, should be abandoned? No; but they should only intervene in answer to very precise indications.

It is evident (continues M. Danion, after setting forth the bearing of heredity on paralysis) that, if facial paralysis is an accusatory sign of nervous debility, it is not necessary to follow a treatment solely local, but also a general treatment; and consequently, static electricity, which constitutes the tonic *par excellence* of the nervous system, would again find its indication, but to the exclusion of all active local action. From the preceding considerations he concludes briefly:—

1. That not only the cure of peripheric facial paralysis is possible by electricity, but that this cure is the rule. This conclusion applies equally to contractions, with this restriction, in one case as well as the other, that when the affection is serious this one is long and occasionally incomplete.

2. That the static treatment, in a general way, and in every case, especially as it is applied at the Salpêtrière, is absolutely useless.

3. That faradaic and galvanic applications, even tolerably energetic, should be excluded from the treatment, especially in the first months of the affection, as predisposing to contractions, and as being even susceptible of determining them.

4. That these contractions are a frequent termination of the affection, and that there is reason to ask whether badly directed electrical treatment should not be, to a certain extent, held responsible for this frequency which does not appear to have struck any observer before their use.

5. That the best method of treatment consists in the application of voltaic currents of 5 to 7 milliampères, applied stabilely and weakly on the trunk of the facial nerve and the length of its terminal branches, an application which may be usefully made from the commencement of the affection.

6. That this same therapeutic can produce remarkable results when it is directed against contractions. These results appear also constant, conditionally, I believe, on the employment of very weak intensities.

DISRUPTIVE DISCHARGES IN LEAD CABLES.

By C. H. RUDD.[*]

IN coming before the Association at this time with the subject named, my principal object is to consider the experiments of Mr. E. G. Acheson. An account of these experiments[†] appeared in the New York *Electrical Review*, July 7th, 1888, and was enlarged upon by Mr. Acheson at your last meeting. The results of the investigations suggested two conclusions: First, that the static capacity of a cable is a transforming agency by which a passing current might develope a static charge of greater electromotive force than the electromotive force which produces said current; Second, that a static charge will not pass an arc. These conclusions are radical and cannot fail to attract attention. If they are sound, they have a most important bearing upon cable service. By virtue of the first conclusion, we would be obliged to largely increase the value of cable insulation, or else put on high pressure protectors of a nature to carry a constant stream of sparks. And we would be obliged to ask: Why have we not had a much greater number of burn-outs than we have? By virtue of the second conclusion, the high pressure protectors, if used, would have to go into every section of cable cut off from other sections by lamps. I do not believe these conclusions to be sound, and expect to show that they are not. I question the first because it conflicts with the well-known law that the electromotive force of a static charge cannot exceed the electromotive force of the charging source. This law is as well sustained in daily practice as is Ohm's law. If the results of an experiment point to the overthrow of a long established principle, the experiment itself will bear inspection.

Let us look at the experiment from which the first named conclusion was drawn. Fig. 1 is an exact copy of Mr. Acheson's diagram. H is an alternating dynamo, T is a transformer in which a portion of the wire is used for both primary and secondary; R is a switch to aid in obtaining different degrees of pressure; E is a switch with which to break the secondary circuit; Y is a switch with which to break the primary circuit; C and D are posts supporting points A and B. The distance between points, A and B, is adjusted by means of pointer P and scale S; G is a piece of fusible wire for safety; K is a condenser. Now let us suppose condenser K to be disconnected for a moment. It was in that form that the first step was taken. We are told that by rupturing the circuit at E, sparks were obtained between A, B of various lengths according to the position of switch, R. This is plainly impossible. To open switch, R, is but another form of increasing the distance between A, B, and we know that such increase would not cause a spark at A, B. I do not deny that sparks were obtained in the experiment, but I do deny that sparking conditions were shown in this diagram. There are no explanations offered by which the sparking conditions can be understood, and explanations would be valueless in this case, for if the sparks occur in any roundabout way, the experiment becomes simply an electrical puzzle without bearing upon the subject under consideration. The investigator seems to assume that everybody will agree that ruptures of circuit and sparks are inseparable. This assumption is without support. When ruptures produce sparks, it is because accompanying conditions are favourable. For instance: If a closed circuit is relieving two points of electrical strain (see points A, *b*, fig. 2) and said circuit should be ruptured, say, at E, points A, B, would have to bear the strain, and a spark might pass between them. We do not find such tendencies to spark in the work shown. From the nature of the investigation, it is manifest that the first step in the experiment should have been to produce sparking conditions such that the sparks would depend on pressure only, after which the effect of adding condenser capacity could have been properly observed. Inasmuch then as the experiment shown to us lacks the vital element necessary to make it demonstrative, every deduction made from said experiment must fall to the ground. The subject under investigation by Mr. Acheson is treated of by Gordon under the head of secondary condensers. A secondary condenser (see fig. 3) is said to add to the burning power of a spark. If Mr. Acheson had made a proper series of experiments in the laboratory, and had then desired to carry his work over into practical life, he would have first obtained a cable carrying heavy current, the cable having in it a spot so weak that the direct pressure was able to break through. In such a case he would have sparking points around which he might connect his secondary condenser, and observe its effect upon the burning power of the spark. He would, however, require some sort of electrical microscope with which to make his observations. That any ordinary method of noting the effect of a condenser upon the spark which I have described would be of no value, is manifest, when we consider that a condenser of one microfarad charged to a voltage of twenty-five hundred would hold ·0025 coulombs. A current of one ampère carries one coulomb per second. As it is coulombs which determine the destructive power of a spark, it is plain that when direct pressure begins to break through a weak spot in the cable, the addition to its destroying power, which it received from the condenser capacity of the cable, is extremely insignificant. To sum up my position concerning Mr. Acheson's first conclusion, I will say that the static charge in an ordinary cable is a negligible quantity when compared with the regular current flowing, and the electromotive force of said charge cannot be greater than the electromotive force of the current from which it was derived. Therefore, in considering the character and thickness of insulation, we have nothing to take account of but the primary pressure which bears upon the insulation. Mr. Acheson's second conclusion, viz., that a static charge will not pass an arc, virtually declares an arc circuit to exist as a

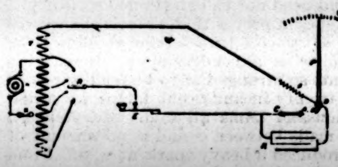
FIG. 1.

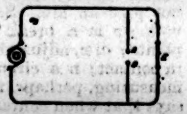
FIG. 2.

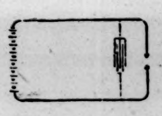
FIG. 3.

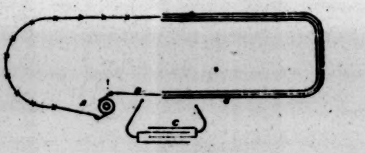

FIG. 5.

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[*] Paper read at National Electric Light Convention, Chicago, February, 1889.

[†] See the ELECTRICAL REVIEW, September 28th, 1888.

number of sections in a solenoid insulated from each other, and in that connection the statement is made that each separate section comes under separate strain every time that the circuit is shut down. I think that I have already satisfied you that we may hold our old ideas concerning the electromotive force of a static charge; therefore we need not fear that an imprisoned charge would do any more harm than the current did from which it came. If we charge an ordinary condenser from a battery, and the condenser does not break down, we do not apprehend that the condenser will break down when we disconnect the battery. There is in the minds of some people an idea that static electricity, when it begins to move, produces a current possessing different properties from current formed by other electricity under the same conditions. This idea is unsupported, and need not be entertained seriously.

But let us see how Mr. Acheson proves that a static charge will not pass an arc. See fig 4. T is a transformer yielding 2,067 volts; S is a break switch; W is a condenser; A, B, sparking points; C, B, adjustable points so arranged as to be readily placed in contact; L a circuit of twenty incandescent lamps in series, measuring, perhaps, four thousand ohms all told. Mr. Acheson says that when contact was made between C and D, no amount of rupturing the circuit at S produced a heavy spark at A, B. From this the conclusion is drawn that the arc is an effectual barrier to the passage of static charge. Let us see. If we have an arc burning at C, D, it would expire simultaneously with the arc which would form at S when S is opened. Therefore the retardation spoken of by Mr. Acheson was due to the break at C, D, D, and not to the arc at all, the arc having expired before the observation under retardation was made. To sum up my position as regards the second conclusion, it is evident that the arc affords free passage to ordinary currents, and we have nothing to indicate as yet that the arc makes distinction between the static charge in motion and other electricity in motion. It is also evident that the insulation of a cable does not undergo strain at shutting down, due to the static charge. Mr. Smith referred at the last meeting to some sparks observed when an arc circuit was shut down. These sparks may be readily attributed to magnetic discharge from the lamps.

I will now speak of an experiment in which I assisted last summer. The experiment is one which Mr. Sunny described before this Association in August, 1888. 1,000 feet of lead-covered cable was laid out upon an ordinary dry floor. This cable was connected as a loop into a working circuit. When first connected up, condenser C could be strongly charged by placing it in circuit between B and S, fig. 5. At first sight it seemed that Mr. Acheson's position was confirmed. An attempt to repeat this experiment on the following day resulted in failure. Another attempt on the third day succeeded. I arrived at this stage of the proceedings. Upon examination, I found that different working circuits had been used each day. The leading idea in the experiment was that if a current would create a static charge of a nature unlike said current the results should be obtainable from any working circuit. When I learned the conditions of the various experiments, I affirmed my belief that the results obtained were of the most commonplace nature, and requested that the steps in the experiment be repeated. This was done. We found that when we put the extra cable into a circuit entirely under cover scarcely a sign of charge could be seen in condenser, C, but upon plugging into a circuit exposed to the weather, a definite charge was obtained. We then returned to the covered circuit. Results were same as before, viz., no charge. We then put a ground at A. This gave us a strong charge. We then began to observe the polarity of charge, and found that we could reverse the polarity by putting the loop in at A, and the ground at B. This change removed all ideas that the results obtained were out of the ordinary, and let us square down upon the common principles of every-day life. The shield, S, was a ground of some valve, so we concluded that we had been trying to see if we could get a charge out of a working dynamo by connecting a condenser between A and the ground with a ground at B; and again if we could change the polarity of the charge by putting the condenser between B and ground with ground at A, fig. 6. A rather simple experiment when stripped of its useless features.

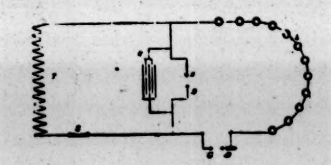

FIG. 4.

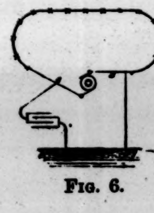

FIG. 6.

In conclusion, I will say that if disruptive discharges occur in properly insulated cables, we must look for the cause in those sources of high pressure which exist in nature. I do not believe that burn-outs can be ascribed to any one cause, but that each individual case has its own individual cause. In practice we must provide insulation strong enough to meet the daily strain and suitable devices to prevent the accumulation of charge from outside sources of greater pressure than the insulation will bear. As yet we have no proof that high pressure protectors are required anywhere outside of the station from which the wires start. Mr. Acheson says that the greater number of grounds or burns-out occurring on arc light circuits are at the terminals of the lead or at the joints, and says that such a state of things would be naturally caused by the greater density of the static charge at these points. This statement strikes me as a singular carrying over of ideas obtained in laboratory work with purely static electricity and arbitrarily applying them to entirely different conditions. The natural static charge in a cable, due to the distribution of the working electromotive force of the current in the cable, must necessarily be governed in its distribution by the force from which it originated. The shape of the conductor cannot act in the matter of this kind of static distribution, as the shape of an insulated conductor would act upon a purely static charge. This remark of mine about distribution may not be treated of by any of the men who write books, but I confidently appeal to my hearers for support. As regards burn-outs occurring at terminals and joints, we know that great care is required to make these points equal to the rest of the cable in a matter of insulation. I do not see how it can be known that burn-outs at such places are not due to accident in construction or neglect on the part of the workmen.

ARC LAMPS AND THEIR MECHANISM.*

By PROF. SILVANUS P. THOMPSON, D.Sc., M.I.E.E.

AN arc lamp being an apparatus for transforming the electric energy supplied to it through the conducting wires into heat and light, it obviously cannot be expected to give a steady illumination unless it can be so arranged and operated that, in the first place, the rate at which it appropriates and transforms the electric energy is constant, and that, in the second place, the circumstances attending this transformation (in respect of the triple relation between the quantity of heat evolved, the degree of temperature, and the emissivity of the incandescent surface), also remain constant. The first of these two provisos relates to the operation of the system of lamps and dynamos (or other means of electric supply) acting conjointly; the second of them relates solely to the quality of the carbon pencils used as electrodes.

As the latter is a simple matter, it may be disposed of first. Suppose the pencil to be composed of a homogeneous carbon, the physical properties of which, such as hardness, specific thermal capacity, conductivity for electricity, conductivity for heat, emissivity, &c., are constant; also that they are cylindrical and of given diameter. Then it follows that if energy is being expended at a uniform rate in heating the tips of a pencil it will be maintained at a uniform temperature, and the amount of light emitted per square millimetre of the surface will be constant, and as the section is constant, the rate of consumption constant, and the pencil homogeneous, the form once acquired by the incandescent tip (whether positive crater or negative peak) will remain constant. It may be remarked, in passing, that the researches of Captain Abney have shown that the white light of the incandescent carbon surface of the crater at the positive pole of the arc is always of precisely the same composition in respect of the relative proportions of waves of different colours. This most important observation indicates beyond doubt that the temperature of the actual light-emitting surface is always the same. Indeed, this ought to be the case if the latent heat of vapourisation of carbon be a positive quantity. When the surface attains this temperature, volatilisation begins; and when so begun the temperature cannot rise further, any more than ice can be raised above its temperature of fusion. The limiting temperature of the voltaic arc is the temperature of volatilisation of the material of the electrodes. This is, in itself, a reason why the introduction of all known foreign substances whatsoever into the carbon pencils of the arc is found to lower its intrinsic brilliancy; for all known elements have a lower temperature of volatilisation, and all compounds are dissociated at arc temperatures.

If, then, we may assume homogeneity of the carbons to be used, the steadiness of the arc light will depend solely upon the maintenance of a steady rate of appropriating and transforming electric energy. How a want of homogeneity may be compensated for in the actual working of the lamp is a point reserved for consideration later.

The rate at which electric energy is appropriated from the wires, and transformed in the lamp into heat and light, always depends both upon the construction of the lamp and upon the conditions imposed upon the system of electric supply. This is a mere consequence of the fact, well known to every electric engineer, that the amount of electric energy per second appropriated by any electric device, motor, or accumulator, is itself the product of two quantities—the current, and the pressure (or potential) at which the current is supplied. To put the matter in electrician's language, the number of *watts* of electric energy per second appropriated by the lamp † is equal to the number of *ampères* that flow through it multiplied by the number of *volts* that may be applied as a difference of potentials between its two terminals. To keep constant the *product* of the ampères and the volts is the practical problem which the mechanism of the arc lamp must be designed to solve.

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* Read before the Society of Arts on Wednesday evening, 6th March, 1889.

† Strictly speaking, the actual number of *watts* utilised in the arc is somewhat less than the whole number received from the supply, as a portion of the energy is expended in passing the current through the regulating coils, and another portion is lost in consequence of the resistance offered by the pencils of carbon themselves, and is merely expended in warming them. We may

A point of much theoretical interest, and in reality of great practical importance, is the fact, long disputed, now established beyond question, that the arc itself does not act simply as an added resistance in the path of the current, but exercises also a counter-electromotive force, and tends to set up an opposing current. The apparent resistance of the arc resembles that of an electrolytic cell, or that of an electric motor when running, or, that of a thermopile when a current from an external source is passed through it. The current which flows through the arc arouses, by a species of polarisation, an opposing electromotive force. The simplest fact in proof of this is that, unlike any ordinary conductor, the apparent resistance of the arc is not proportional to its length. The apparent resistance of an arc two millimetres in length between the carbon tips is not double that of an arc one millimetre in length, nor anything near double. The fairest way to investigate the matter is to make a series of experiments with arcs of different lengths, the current being independently so regulated as to be maintained of the same strength in each case. There appears to be a true resistance proportional to the length, and a back-electromotive force which in steady arcs, and with currents of from 7 to 15 ampères, appears to be about 38 to 39 volts. When the arc hisses, as often happens if the length of it be very short, the back-electromotive force fluctuates very much, but always drops to something under 20 volts. Except in the case of constant current circuits, this causes a sudden increase of current when the lamp begins to hiss, and it may be noticed that the light, though unsteady during hissing, is brighter at the negative pole of the arc.

Hitherto all guesses as to the cause of this counter-electromotive force have been very vague, not to say wild. To account for 39 volts of polarisation on any hypothesis that it is due to electrolytic or thermo-electric action, is to suggest causes which are, to say the least, wholly inadequate. The explanation which for the past two years I have been in the habit of suggesting to my students, and which has not been otherwise published hitherto. is as follows:—Every reversible phenomenon which the current can itself produce, and which requires an expenditure of energy for its production, necessarily implies the exhibition of a counter-electromotive force. One has only to look at the cases of the reversible chemical action in a cell, of the reversible magneto-mechanical action of a motor, the reversible heating effects of a thermo-electric junction, to comprehend this. Now the phenomenon of volatilisation is a reversible one: give to the solid carbon at its volatilisation temperature the necessary latent heat, it is changed to vapour; take from the vapour its latent heat, it condenses back to solid carbon. The arc under normal circumstances is the seat of an actual evaporation of carbon at the positive pole, as well as of a combustion at both poles. So far as any data exist, it appears that the excess of carbon consumed at the positive pole by an ordinary continuous current is about 0·5 grammes per ampère hour. If we knew the latent heat of volatilisation of carbon per gramme we could calculate *à priori* the necessary minimum electromotive force at the positive pole, which would obviously represent the counter electromotive force so far as it is situated at that point. With long arcs the excess of consumption of the positive pencil over that of the negative is both less and more regular than that which occurs with short arcs. With short arcs three other phenomena occur which are important in this connection. Firstly, the short arc is liable to whistle or hiss, giving evidence of instability; secondly, it frequently gives rise to "mushrooms," or irregular growths of carbon upon the apex of the negative pencil; thirdly, when it hisses the counter electromotive force becomes very unsteady, but appears to have an average value about half that of the steady long arc. It is worth while to throw out the suggestion that the condensation of carbon at the negative pole, in the short arc, is accountable for the change in electromotive force, and for the instability which manifests itself by the hissing sound.

Passing from these conjectures to the construction of lamps for the production of light by the arc, we are now prepared to lay down the points which must be provided for in every arc lamp. It must be emphatically pointed out at the outset that, as the performance of a lamp depends upon the conditions under which it is supplied with electric energy by the circuit, the design of the lamp necessarily also depends on those conditions. In the present state of the art of electric distribution we may classify the conditions of electric supply under the following heads:—

I. CONTINUOUS SUPPLY AT CONSTANT POTENTIAL.

In this case the arc lamps are arranged either simply all in parallel or in parallels containing two in series, the currents being divided by mains and branches to the lamps. At least 55 volts should be allowed between the mains for single arcs. Practice shows that arc lamps in parallel burn more steadily if a resistance wire of ·25 to 1·0 ohm be included in the lamp circuit. Taking the back electromotive force of a steady arc at 39 volts, it is obvious that the excess of the volts at the mains over this represents the volts used in driving the current through the actual resistance in the main circuit of the lamp. This resistance consists of four parts—the true resistance of the arc itself, which may vary from $\frac{1}{10}$ to $\frac{1}{2}$ ohm; the resistance of the carbon pencils, which averages about 0·15 ohm per foot per plain carbons; the resistance of the main circuit coils, which varies in different lamps from 0·05 to 0·2 ohm; and the resistance of the wire introduced for steadying the lamp. In a 10-ampère lamp, working at 55 volts at the mains, 16 volts remain, after deducting 39 for the back electromotive force, and these 16 are approximately distributed as follows:—2 volts in the arc itself, 3 volts in the carbons (say, 2 feet long in the total), 1 volt in the main coil, and 10 volts in the steadying resistance.

II. CONTINUOUS SUPPLY WITH CONSTANT CURRENT.

In this case the arc lamps are arranged in series, the whole of the current going from one lamp to the next, and returning to the dynamo after having traversed successively all the lamps. This is, *par excellence*, the arc light system of distribution, the parallel system at constant potential requiring heavier mains. As the lamps arranged in series tend to steady one another, it is not necessary to allow more than 45 to 50 volts per lamp, including the ordinary lengths of cable from lamp to lamp. From 5 to 10 ampères is the usual current for arc lamps in series.

III. ALTERNATING SUPPLY AT CONSTANT POTENTIAL.

In this case, also, the lamps are usually arranged as in the first case, the only difference being in certain structural details, such as lamination of iron cores.

IV. ALTERNATING SUPPLY WITH CONSTANT CURRENT.

This case can hardly be said to be practical, though alternate current dynamos, capable of supplying 6 or 8 lamps in series, have been constructed in past years.

The supply systems, whether continuous or alternating, must be assumed, for the purpose of this paper, to perform efficiently what they profess—namely, to maintain constant one of the two factors of the electric power which they supply to the distributing system. In each case it remains for the mechanism of the lamp to effect such adjustment as will maintain constant the other factor of the product. If the condition of supply is "at constant potential," then it is for the lamp itself so to adjust its carbons as to keep the current through the arc constant. If the condition of supply is "with constant current," then the lamp must adjust its carbons to maintain between them the requisite potential. Hence the differences which are necessary in construction between those lamps which are to work "at constant potential" (in parallel) and those which are to work with constant current (in series). These differences, as will now be shown, chiefly affect the "feeding" mechanisms of the lamp.

In discussing the necessary mechanisms of arc lamps, no further reference will be made to lamps of the Jablochkoff candle type, nor to those with abutment blocks of marble ("Sun" lamp, &c.),

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calculate the former loss as follows:—Let E represent the whole number of volts from terminal to terminal, and let i represent the whole current supplied, then the whole number of watts supplied is Ei. Let the *ohms* of resistance of the regulating coils in the main circuit be called a, and that of the shunt coils be called b, that of the carbon pencils themselves, c, and that of the resistance coils sometimes used in the main circuit to steady the arc, r. Also, in the case where the lamp has a shunt circuit, let the portion of i which passes through the carbons be called i_1, and that which goes through the shunt, i_2; so that $i_1 + i_2 = i$. The losses are then as follows:—

ai_1^2 = watts lost in main-circuit coil;
$bi^2 = E^2 + b$ = watts lost in shunt coil;
ci_1^2 = watts lost in warming carbon pencil;
ri^2 = watts lost in the resistance coil.

The resistance of carbon pencils is usually small, and may be materially reduced by a thin coating of copper. The carbons used in commerce (11 to 15 millimetres in diameter) vary from about 0·15 to 0·2 ohms per foot, if plain, and from 0·001 to 0·09 if coppered. Cored carbons have a higher resistance than uncored. Carbons cut from solid gas-coke have from five to twenty times as much resistance as those made by the usual modern processes. When lamps are run in series, the resistance offered by the pencils is of more importance; for example, a set of 50 lamps newly trimmed with long carbons may offer 25 ohms more resistance than when all the carbons have burned down short. The resistance, a, of the regulating coils that are in the main circuit differs in different lamps, but may be taken at from 0·05 to 0·2 ohms. The resistance, b, of the shunt coils is seldom less than 200 ohms, and may be as much as from 400 to 500 ohms. Of the volts, E, applied to the lamp only a part is utilised, the lost volts being accounted for by the resistances in the path of the current. If these are deducted from the applied electromotive force, there will remain a certain number of volts, which we may call e, which are available as a useful difference of potential at the arc itself. To measure e directly, one has only to apply a voltmeter, making the contacts of its two leading wires to the two carbons at points respectively just above and just below the incandescent tips. The watts actually utilised in the arc are then calculated as the product ei_1. As shown above, e is less than E, and, indeed, may be considerably less, the lost volts depending upon the resistances introduced, and on the current flowing through them. If E is constant, e will not necessarily be so, but will be very nearly if i is also constant. Also i_1 is less than i in all lamps that have a shunt regulating coil, but is not usually more than from 3 to 5 per cent. less than i, so that in the cases where i is kept constant, i_1 will be nearly so also.

nor to the so-called incandescence arc ("semi-incandescent") lamps, nor to those with curved carbons (Heinrichs's type, nor yet to those horizontal carbons (De Mersanne's, Solignac's, &c.).

Necessary Mechanism of Arc Lamps.

[A.] *Driving Power.*—In every lamp some means or mechanism is required to propel the carbons toward one another as they burn away, gravity being by far the most common agency for doing this.

[B.] *Striking Mechanism.*—In every arc lamp it is requisite to provide a mechanism for bringing the tips of the carbon pencils into contact, and then parting them asunder to the requisite distance across which the arc or flame plays. If, as in most lamps, the carbons are in contact when the lamp is out of action, then a mechanism is required simply to part them as soon as the current is turned on. The operation of producing the arc by parting the carbons is known as "striking" the arc. The mechanism must be automatic, so as to come into action not only when the current is first turned on, but at any subsequent time if from any cause the arc fails. An adjustment, *b*, of the striking mechanism is also usually added to permit of regulation in the length of the stroke or initial distance between the poles.

[C.] *Feeding Mechanism.*—As the carbons burn away, one or both of them must be propelled forward to maintain the arc at its proper size. This action is called "feeding" the arc. This action ought to take place by small and imperceptible amounts, and as the rate of consumption of the carbons is continually varying, even with carbons of the best modern manufacture, the lamp must itself regulate the rate at which the pencils are propelled forward in automatic correspondence with the consumption for the time being. Further, since the presence of soft and more readily volatilised portions in the pencils seems to be unavoidable, provision ought to be made so that, whenever the pencil burns down to such a portion, causing a sudden increase in the volume of the flame or arc—technically called a "blower"—the mechanism of the lamp ought at once automatically to draw apart the pencils to a slightly greater distance. A lamp which has a *retractile* motion in either its feeding or its striking mechanism is superior to one that has not, as it can be used with cheaper and less pure brands of carbons. An adjustment, *c*, for regulating the frequency or range of the feeding movements is usual.

[D.] *Replacement Mechanism.*—When the pair of carbon pencils has burned away, the lamp trimmer has to replace the stumps by a new pair of long carbons. In order to admit these, the carbon holders must be pushed apart to their widest extent. Special mechanical devices for allowing this motion to occur have to be provided in some forms of lamp, whilst other forms need no special device.

[E.] *Moderating Mechanism.*—To prevent the carbon from making too sudden motions, it is usual to add a moderating device, such as a dash-pot, or, in the case of those lamps in which there is a train of wheels, a fan or a governor.

So far, the devices enumerated have been such as are common to all classes of lamps. Those which follow are only required in particular types of lamp.

[F.] *Focussing Mechanism.*—In all those cases where it is desired that the luminous points should occupy a fixed position in space, some additional mechanism is necessary to make the arc lamp keep its focus. In lamps designed for the mere lighting of area, this is not important, and in the vast majority of these the upper carbon descends whilst the lower carbon (the negative) is fixed; the luminous point slowly shifting downwards as the carbons consume. All devices for causing the carbons to move forward at such relative rates as to keep an approximately fixed position for the arc will be discussed, together with their methods of adjustment, *f*, under the heading of focussing mechanism.

[G.] *Change-over Mechanism.*—Lamps that must run for many hours continuously must be supplied with two pairs of pencils, because it is neither practicable nor advisable to use pencils of extreme length. In the double lamps it is appropriate to provide such arrangements as shall cause one pair of pencils to come into operation first, and when these are consumed away, shall change-over the action, either by electrical or by mechanical devices, so that the second pair of pencils shall come into operation.

[H]. *Cut-out Mechanism.*—Lamps intended for series working must be provided with some contrivance to prevent the extinction of the whole series when from any cause there is a failure of the light in any one lamp. The usual device is a sort of automatic relay arranged in connection with each lamp, to come into operation in the event of its failure, the operation of the device being (1) to cut the faulty lamp out of circuit by simply short-circuiting it, or (2) to substitute for it a wire of suitable resistance, or (3) to replace it by an auxiliary lamp. The device for performing either of the two former operations is technically known as a "cut-out."

Supplementary Contrivances.

In addition to the eight distinct species of contrivances above enumerated, there are numerous details which might be further classified; such, for example, as devices for *clamping* the carbon pencils to their respective holders in true allignment; devices for raising and lowering the lamps. For these, however, there is no space. Neither is it possible to enumerate the devices which have been suggested [Staite, Siemens, Brockie, Andrews, Crompton, Swinburne, and others] for *compensating*, in lamps whose action depends on the weight of the descending carbon pencil and its holder, for the diminution of pull as the pencil is consumed.

Schedule of Mechanisms.

A schedule embracing the eight heads above enumerated, if supplemented by statements of the gauges and resistances of the wires used in the windings of the coils, affords a systematic and very convenient method of tabulating the facts concerning the construction of any arc lamp. An example of such schedule, filled up with the data of one arc lamp of recent pattern, is given at the end of this paper.

Electro-magnets for Arc Lamps.

As the electro-magnet plays so essential a part in the striking, feeding, and cut-out mechanisms of lamps, a short digression upon the particular forms of electro-magnets appropriate to arc lamps is not out of place. The ordinary treatises on electricity have little to tell about the special properties of different forms of electro-magnet; indeed, this all-important organ in modern electrical engineering has received very inadequate attention from writers on electricity. It is a familiar fact that the attraction of a horseshoe-shaped magnet, whether of steel or iron, varies very greatly with the position of the iron armature, being great at small distances, but very rapidly falling away as the intervening space is increased. To devise a form of electro-magnet whose attractive power shall be exerted over a fairly long range, was at one time one of the practical problems of electricians, and it has been solved in various ways. The attraction which a solenoid, or tubular coil, exerts, when traversed by a current, upon an iron core introduced within its aperture, is not, in any position of the core, nearly as great as that exercised by an electro-magnet of horseshoe type, constructed of equal amounts of metal, and energised by an equal current. On the other hand, the feebler pull of the solenoid upon its core is exerted through a very extended range. And by making the core of conical form, or by winding the coils of the solenoid in a conical fashion, it is possible still more completely to equalise the pull over a long range. Solenoids with cores are used in several well known types of lamps in which a long travel is required. On the other hand, since the operation of striking the arc requires a short motion not exceeding one-twelfth of an inch, or two millimetres, in all those types of lamp in which a special electro-magnet is used simply to strike the arc, a form of electro-magnet is required which will exert a powerful pull over a short range. Further, for working certain clutch mechanisms and the like, it is desirable that a form of electro-magnet should be found which, whilst having a travel of, say, one inch, should exert throughout the whole of that range a fairly strong pull, increasing, of course, toward the end. Experiments show that the special forms of electro-magnet may be tabulated as follows:—

(*a*) *Short-range Magnets.*—1. Horseshoe form, if constructed with short thick cores, thick yoke and thick armature, giving compact magnetic circuit.

2. "Pot-magnet," straight core with external tubular envelope, connected by iron at bottom. Armature, a stout iron disc or lid.

(*b*) *Moderate-range Magnets.*—1. Horseshoe form with long thin cores and armature, giving a non-compact circuit.

2. Solenoid having a short fixed core extending part of the way down, and a second movable core to be attracted in as plunger. The name "stopped solenoid" is suggested as appropriate for this form.

3. Two such as last, having a yoke connecting the two fixed cores, and a second yoke connecting movable cores.

4. Stopped solenoid with plunger attached to an outer mantle [Kennedy's lamp, fig. 10].

5. Electro-magnet with conical poles protruding through hollow in armature [Thomson-Houston lamps, figs. 14 and 25].

6. Electro-magnets with oblique approach of armature [Serrin's, fig. 5; De Puydt's, fig. 23; and many other lamps].

(*c*) *Long-range Magnets.*—1. Solenoid, cylindrical, with longer cylindrical core. Attraction greatest when entrant end of core just reaches the further side.

2. Solenoid, cylindrical, with long coned core entering with the point foremost.

3. Solenoid, conical, with long cylindrical core entering the thicker end of solenoid.

4. Special device for travel of unlimited length. A solenoid constructed in sections, which are switched into circuit progressively ahead of the core as the core travels down* [Thomas, 578, 1882; Lindemann, 16,376, 1887].

It must be borne in mind that the range of an electro-magnet depends on the relative dispositions of the iron parts of the magnetic circuit and of the magnetising copper parts, and in no way upon the question whether the coil consists of a few turns of thick wire, or of many turns of thin wire.

Equalisers.

In sundry forms of lamp special mechanical devices have been introduced for the purpose of equalising, throughout a given range of motion, the otherwise very unequal pull of the electro-magnet upon its armature. Set-up springs with adjustable stops have been used for this purpose. A more satisfactory *equaliser* (*repartiteur*) is the device suggested by the famous conjuror, Robert Houdin, which is depicted in fig. 1. Here the attraction of the electro-magnet, E, for its armature *a*, is transmitted through a system of two curved levers, A and B, which rock on one another at a point of mutual contact which varies the "mechanical advantage" of the system, and partially or wholly, according to the curvature, compensates for the great increase of force as the distance of the armature diminishes.

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* Figures in square brackets relate to patent specification or date.

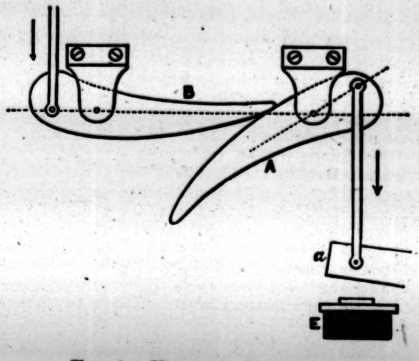

FIG. 1.—HOUDIN'S EQUALISER.

The form of the equaliser of Foucault, as used in the Foucault-Duboscq lamp, is depicted in fig. 2. Here the armature, *a*, which is stiffly pivotted eccentrically to allow of adjustment, is attached to a lever, A, whose fulcrum is at F, and the opposing force of a spring, *s* (itself adjustable by the screw *r*), is applied through the curved rocking lever, B. The vertical arm attached above F carries the detent, D. Equalisers depending on use of a rocking lever are to be found in several lamps. [Serrin's lamp; also Mackenzie, 95, 1882, and Common, 626, 1882.]

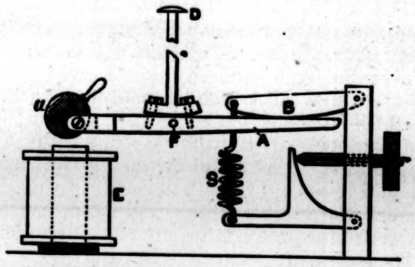

FIG. 2.—FOUCAULT'S EQUALISER.

Returning from this digression, we have now to go separately over the eight items of the schedule, and point out how the various necessities have been met by the ingenuity of various inventors. As it is impossible to mention all instances of carrying out a principle, reference is made only to a few cases, preferably to the best known lamps.

[A.] DRIVING POWER.

The following devices have been used :—

1. *Gravity.*—Descent by its own weight of upper carbon holder [innumerable lamps]; ditto, aided by weights specially attached [Gülcher, 1,915, 1882]; ditto, partially opposed by coiled spring to compensate for consumption [Siemens, 366, 1888]; clockwork driven by weights [Staite, 11,783, 1847]; lower carbon floated upward in mercury [Tommasi, 4,405, 1879].

2. *Coiled Spring.*—Drives by pinion and rack, or pulley and cord [Foucault, 1848, Staite, 11,449, 1846]. Differential action of two coiled springs [Foucault-Duboscq lamp].

3. *Electromagnetic Motor.*—(*a*) Suction of core by solenoid; (*b*) electric motor rotates and drives carbon rod [Bousfield, 523, 1879; Breguet, &c.]; (*c*) electromagnetic vibrator drives carbon rod [Clark-Bowman, 1,182, 1883; Newton, 1,623, 1883; Pieper, 4,133, 1886: Holmes, 769, 1886.]

4. *Hot Air.*—Heated air rising from lamp drives fan to propel carbons. [Varley, 5,656, 1881.]

[B.] STRIKING MECHANISM.

To strike the arc requires mechanical devices; but as these are to be actuated by the current itself, it is appropriate first to consider what electric mechanism is necessary or sufficient to actuate the movement. Assuming that the carbons are initially in contact when there is no current, the current when turned on must part them; the appropriate device is therefore an electromagnet (or solenoid with its core in lieu thereof) having its coils in the main circuit of the lamp. [Foucault, 1847; Staite, 11,783, 1847, and in the vast majority of modern lamps.] If, however, the carbons are initially apart, the lamp must itself bring them together; and the appropriate device to actuate this movement will be an electromagnet (or solenoid) connected as a shunt, and therefore having fine wire coils of high resistance. Such an arrangement will bring the carbons together by the action of the by-pass current, and as this falls almost to zero on the contact of the carbons, they will be at once parted (and the arc struck) by the opposing force: this force may be that of gravity [Lontin, 1875] or a spring [Lever, 2,092, 1882; Thomson-Rice, fig. 33]. The disadvantage of this second method is that the initial resistance of the whole series of lamps standing with their carbons parted is enormous unless there is a cut-out circuit. Another method of striking the arc is by cutting out a main circuit electromagnet [Crompton, 346, 1882; Bright, 377, 1882].

The modes of parting the carbons are various :—

1. Drawing both carbons asunder by gearing [Foucault-Duboscq lamp].

2. Drawing down the lower carbon by electromagnet placed in base [Staite, 11,783, 1847; Serrin, Breguet, Sellon, Newton, Pieper, Holmes, &c.], or by electromagnet situated at top [Crompton "E," 1881; Gramme; Silvertown Co.; Fein, 1886].

3. Lifting upper carbon rod [Roberts, 14,198, 1852; Slater and Watson, 212, 1852; and the vast majority of modern lamps, Brush, Siemens, Crompton, Pilsen, Brockie-Pell, Thomson-Houston, &c.], or lifting upper carbon by an electro-magnet situated in the carbon rod [Abdank, 1884]; or by lifting bodily the upper carbon and the whole of the feeding train [Crompton, 346, 1882; Fyfe and Main, 3,821, 1881; Berjot, Wood, Hochhausen, Maxim, 1,649, 1880; Gümpel, 253, 1881, &c.]; or by rocking the feeding train around a centre [Brockie, 2,370, 1882; De Puydt, fig. 23, p. 353].

The mechanical devices for performing these various actions are numerous, and their action is complicated by the endeavour of many inventors to cause the same mechanism which initially strikes the arc also subserve the purpose of feeding the carbons. In some lamps, however, these functions are kept separate. An example of a lamp in which the striking and feeding mechanisms are kept separate is afforded by the Breguet lamp (fig. 3), in which an electromagnet draws down the lower carbon holder to strike the arc, whilst the feeding is accomplished in the subsequent gradual descent of the upper carbon. In the lamps of Newton, Sellon, and Holmes, there is used the special form of short-range electromagnets, *a* (2 in the list), having a central core and external tube of iron. There is a very numerous class of lamps in which a clutch is caused to grip the upper carbon holder, and then to raise it so as to strike the arc; the same clutch being subsequently so operated, as to permit the carbon holder—a smooth rod—to slide down by degrees as required, to feed the carbon pencil forward. Such devices are best considered under the heading of feeding mechanisms.

The adjustments of the striking mechanism may be of two kinds :—(1) adjustments of range, such as limiting stops and set screws; (2) adjustments of force, such as the regulable spring shown in fig. 1 at the bottom.

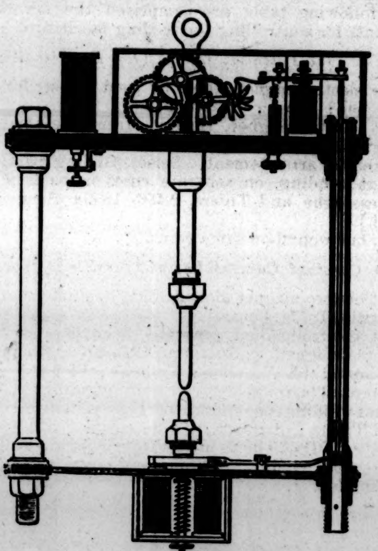

FIG. 3.—BREGUET LAMP.

The main-circuit electromagnets, and solenoids, used for striking the arc, are wound with a wire of large enough section to carry the required current without undue heating, and are of small resistance. The weight of copper wire employed varies from one to four pounds; and the resistance varies from 0·05 to 0·2 ohms.

[C.] FEEDING MECHANISM.

The electric devices here differ in the case of lamps for parallel working and lamps for series working.

(*i.*) *For Lamps in Parallel.*—Assuming that the supply mains are kept at constant potential, then the lamp mechanism must be responsible for keeping the other factor of the electric power, namely, the current through the lamp, at a constant value. That is to say, whenever by reason of the burning away of the carbon points the arc grows long, offering more resistance, and, therefore, reducing the current below its normal value, the lamp must automatically feed the pencils forward, and so re-adjust the current. It is obvious that, in this case, the weakening of the current through the lamp may be caused to bring the feeding mechanism into operation by the use of an electromagnet (or solenoid) in the main circuit. For if the armature of this electromagnet be held back by a spring or weight which only just counterbalances the pull of the magnet when the current is normal, the weakening the current will at once cause a movement of the armature which may be utilised to relax a clutch, lift a detent, or release an escapement. And it is also obvious that in this case it is possible to arrange the same electro-magnet which strikes the arc to actuate the feed. Examples of the use of a single main circuit electro-magnet to actuate both the striking and the feeding mechanisms are to be found in the Serrin lamp, in the Gülcher lamp, and in the Brush lamp as arranged for parallel working.

(*ii.*) *For Lamps in Series.*—Assuming that the dynamo is doing its duty, and keeping the current constant, then in this case the lamp mechanism must be responsible solely for keeping constant the potential between the terminals. Whenever by reason of the burning away of the carbons the arc lengthens and offers more resistance, if the same current is still supplied to it and forced through this greater resistance, it will burn more brightly, and the difference of potentials between the terminals of the lamp will rise above its normal value. The lamp must then automatically bring its carbons nearer, and readjust the potentials to the proper number of volts. It is obvious that the appropriate device to actuate the feeding mechanism must, in this case, be something that can play the part of a voltmeter; and will actuate the mechanism when the volts rise above their normal value. Practical voltmeters are of two kinds: (*i*) those which depend on the magnetic effects of the current that will flow through a wire of high resistance placed as a shunt across the two points between which the differences of potential exists, and (*ii*) those which depend on the heating effects of the current in such a wire. Either of these effects may be used to control the feeding mechanism of arc lamps; that is to say, the feed must be controlled by a shunt circuit, which will actuate the mechanism as soon as the potential rises above its normal value. The usual device is an electro-magnet (or solenoid) of fine wire, and of high resistance (from 200 to 400 ohms), the armature of which is counterbalanced by the force of a spring, or by gravity, or by an opposing main circuit electro-magnet (or solenoid). An alternative device, not, however, in general use, is a long thin platinum wire, which when heated by a current above the normal value will expand and actuate the feed. Thermal expansion has been attempted as a method of regulation by several inventors. [Lontin, 2,074, 1877; Siemens, 2,281, 1878, and 2,110, 1879; Munro, 1,626, 1882; Edison, 2,072, 1882; Pollak, 1888, &c.

In the following table are comprised the several electrical arrangements for controlling the feeding mechanism:—

(*i.*) *Constant Potential Lamps* (*for Parallel Working*).

(*a.*) Series electro-magnet, same as used for striking. [Serrin; Gülcher; Brush; Crompton, &c.]

(*b.*) Series electro-magnet, separate from the striking electro-magnet. [Fontaine.]

(*c.*) Differential arrangement. Series winding partly opposed in shunt winding, on separate cores or parts of mechanism. [Lacassagne and Thiers, 2,456, 1856; Siemens; Brockie-Pell.]

(*d.*) Ditto, but wound on same cores.

(*ii.*) *Constant Current Lamps* (*for Series Working.*)

(*a.*) Shunt electro-magnet alone, acting against gravity or spring. [Lontin, 1877; Lever.]

(*b.*) Shunt electro-magnet separate from the striking (series) electro-magnet. [Numerous lamps. Breguet (fig. 1); Crompton "E;" Sellon; Gramme; Pieper.]

(*c.*) Differential arrangement. Shunt winding pulling against series winding, on separate part of mechanism. [Lacassagne and Thiers; Siemens; "differential;" Pilsen; Crompton-Cragg "DD;" Thomson-Houston; Brockie-Pell; Kennedy.]

(*d.*) Differential winding. [Numerous lamps. Brush; Weston; "Simplex."]

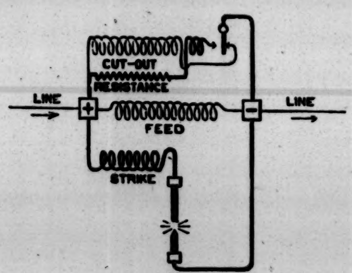

FIG. 4.

The typical arrangement of circuits for lamps that are to be run on a system of arc lighting in series, is shown in a generalised diagram in fig. 4. The striking coil is in the main circuit; the feeding coil is a shunt, which if wound on the same core as the series coil in any of the differential systems must be so wound that the currents circulate in opposing senses. There is also added a cut-out circuit, having both a shunt coil and a small series coil; but these must be so wound as to help one another's magnetic power, and the small series coil must itself be a shunt to the main circuit of the lamp.

We are now prepared to enter upon the mechanical devices which have been suggested for the feeding mechanism of lamps. These are so varied, and run so curiously into one another, that no classification of them is entirely satisfactory. In a very large class of lamps there is a train of wheel work, usually driven by the weight of the descending carbon rods, the last member of the train being controlled through a detent or brake, by the electro-magnet that is responsible for the feeding of the lamp. Most, but not all, of these lamps have a rack upon the upper carbon rod to drive the train. But the rack lamps differ greatly amongst themselves. Again, there is another class of lamps in which the upper carbon rod is smooth, but is assisted and controlled in its descent by a clutch or clamp, the clutch or clamp being in turn controlled by the feeding electro-magnet. But there are also rack lamps in which a clutch or clamp is applied, not to the rod itself, but to a wheel driven by the descending rack. There are, however, certain main features of classification about which there need be no ambiguity.

(*To be continued.*)

NOTES.

Novel Electric Lighting for the Paris Exhibition.—Improving upon the late Col. Bolton's coloured electric light effects upon the fountains at South Kensington, the electricians to the Paris Exhibition have devised a method by which, while the colouring will be more elaborate and artistic than that at our recent Fisheries and other exhibitions, the electric light will be cast upon the water from some hidden source. It will be remembered that at South Kensington the beam of light could be distinctly seen as it was thrown from the elevated lantern—or lighthouse—upon the fountains and the grounds. The Eiffel Tower is to be surmounted, more than a thousand feet up in the air, by an enormous and powerful arc light, which will illumine the exhibition grounds and many miles of the surrounding district. Incandescent lamps will beautify the tower from the base to the summit, and the lighting of the whole of the buildings will be carried out on a scale not previously attempted anywhere.

Lighting in the Navy.—A trial of the electric lights on H.M.S. *Marathon*, which has been built for the Government by the Fairfield Company, of Govan, took place on Friday. The work of fitting has been carried out for the Fairfield Company by Mr. R. A. Scott, who also fitted H.M.S. *Magicienne* for the same firm.

Electric Light in Strathearn.—Strathearn House, a hydropathic establishment at Crieff, is being fitted with the electric light. To begin with, over 150 lamps are being wired, of which the majority are of 16 C.P., the remainder being of the Sunbeam make of 200 C.P. and 400 C.P. Trotter's dioptric shades are being introduced with splendid effect, and the high candle-power incandescents are found to satisfy the requirements of such an establishment. Electric power is being introduced, and will be largely used all over the building. Messrs. Anderson & Munro, of Glasgow, have secured the contract for wiring, and the work is being carried out well within the Phœnix fire rules. The generating plant consists of a Griffin high-speed gas engine of the double-acting type, giving nearly 24 H.P. on the brake, and running at 200 revolutions per minute. This drives by belting a Paris and Scott dynamo at 850 revolutions, giving 100 volts and 120 ampères. It is intended to lay down a battery of accumulators of the E.P.S. Company's make later on, so as to render the supply of current continuous. The engine room is underground, and as current is to be supplied to some villas in the town, every precaution is being taken to avoid a breakdown. As the managing director of the Hydropathic Company is a director and a large shareholder in the gas interests of the place, things augur well for the electric light. The installation is being carried out under the superintendence and to the specifications of Mr. C. H. Yeaman, electrical engineer, of London.

Electric Lighting at Windsor Castle.—The Queen finds that the introduction of the electric light into the corridor at Windsor Castle is so great an improvement that it will be extended before long to the White, Crimson, and Green drawing rooms, the ball room, and the dining room. Sir John Cowell has long been endeavouring to obtain permission to illuminate all the private apartments which are used for reception purposes by electricity, but the Queen fancied that the light would be too strong for her eyes.

Liverpool and the Electric Light.—At Tuesday's meeting of the members of the Watch Committee of the Liverpool Corporation the application of the Electric Supply Company for the extension of the six years' licence into a 25 years' provisional order received careful consideration, and a small sub-committee was appointed to further consider the advisability of sanctioning or otherwise the making of an application to the Local Government Board.

Dorchester and the Electric Light.—The Dorchester Town Council recently requested of the Gas Company a reduction in the price charged for lighting the public lamps. It has received in reply a reminder that the terms of the contract of 1887 were approved of by the Council, and is informed that, as the cost of producing gas is the same now as it was then, the directors of the company cannot see their way to making any alteration in the price. At the meeting of the Corporation last week Mr. George said he thought the company was pressing the Corporation very hard, because there was a company in London now which was willing to supply the electric light at an equivalent rate to 4s. per 1,000 feet, and in Dorchester they were well situated for the purpose, because the Priory Mill could be utilised to supply a good deal of the power. If the Gas Company pressed them too hard it would be worth while to consider whether it would not be cheaper to introduce the electric light in Dorchester. After further discussion, it was resolved, on the motion of Mr. George, seconded by Mr. L. Tilley, to request the Anglo-American Brush Electric Light Company to give an approximate estimate for the supply of the electric light. Alderman Gregory moved, Mr. G. Davis seconded, and it was resolved to inform the company that the Council did not consider its letter satisfactory, and requested reconsideration of the question with a view to meeting the wishes of the Council.

Curling by Electric Light.—At Edinburgh the other evening a curling match between the Northern Curling Club of that city and the Merchiston Club was played by electric light, Merchiston winning by a majority of 18 points.

The Electric Light at Cowpen.—At the monthly meeting of the Cowpen Local Board, the Chairman asked the Clerk of the Board (Mr. M. W. Sidney) if, in his opinion, the proceedings for lighting the Cowpen district with electricity were all right, as there were rumours in the town that the firm of electricians, Messrs. Nicholson and Jennings, had been stopped. The Clerk then read a letter from Messrs. Nicholson and Jennings, which stated that the local agent of the Thornton and Croft estate had given them verbal notice that he was instructed to remove all existing poles and posts on his estate which had been put up for the electric light, and also to prevent the erection of any works. The Clerk, it appeared, had written the Thornton and Croft trustees at the time when the board determined to adopt the light, asking them to throw no obstacles in the way, but to further in every way the new lighting scheme. This the trustees have not elected to do, and the firm of electricians, backed by the Local Board, are determined to go on putting the electric lighting plant down in spite of any impediments thrown in their way by the trustees of the Thornton estate. The Clerk was instructed to write the electricians urging them on with the work.

Arc Lamp Posts Useful.—According to the *Daily News* "special" there is some virtue in an arc lamp post apart from its conduciveness to illumination. During the floods last week a postman was forced to clasp one of the posts to save himself from being swept away by the strength of the rushing water. He was nearly exhausted when the driver of an hotel omnibus, floundering its way from the station, heard his cries for help, and got near enough to throw him a sack by which to haul him up to the vehicle.

Barnet and the Electric Light.—At the last meeting of the Barnet Local Board a letter was read from the Board of Trade saying their attention had been called to the fact that the roads in the Board's district were to be opened for the purpose of laying underground the wires for electric lighting, and warning the Board that the company had no statutory powers and could not be allowed to do so. It was proposed by Mr. Schmidt, seconded by Mr. Samuels, that the lighting question be referred to the lighting committee, and that Mr. Joel be asked to attend. This was carried *nem. con.*

Newcastle and the Electric Light.—At the last week's meeting of the Newcastle Town Council Mr. T. B. Winter moved the adoption of the report of the Town Improvement recommending the granting of applications from two electric lighting companies for the supplying of electric light to the city. An amendment was moved that the matter should be adjourned, but this was lost, and the report was ultimately adopted.

London and the Electric Light.—Bermondsey has resolved to consent to the application of the London Electric Supply Corporation to the Board of Trade. St. Luke's Vestry has postponed consideration of the matter for a month. St. Martin's-in-the-Fields Vestry has decided to assent to the application of the Electrical Power Storage Company for a Provisional Order. The motion for the adoption of the committees' recommendation was made by Mr. Challice, churchwarden, and seconded by Mr. Towell. Clerkenwell and St. Saviour's (Southwark) Vestries have approved of the applications of both the London and Metropolitan Electric Supply Companies for Provisional Orders, the former requiring, however, that the companies shall repair the roads for three years. St. Margaret's and St. John's (Westminster) Vestry has resolved to object to the applications of some half-dozen companies. The Electric Lighting Committee reported the receipt of communications from the Board of Trade stating that the Board had refused the applications for licences by the Metropolitan Electric Supply Company and the London Electric Supply Corporation, on the ground that in matters of such magnitude Parliament should be afforded an opportunity to review the Board's decision. The committee was still proceeding upon the reference by the Vestry, empowering them to fully enquire into the whole question of electric lighting, with a view to the Vestry undertaking the supply of the light in that district themselves.

Cheltenham and the Electric Light.—An adjourned meeting of the Cheltenham Town Council was held on Monday to take into consideration the report of the Electric Lighting Committee, which gave an approximate estimate of the cost of laying down plant, &c., sufficient for 60 arc lamps of 1,200 candle-power each, and 2,300 incandescent lamps of 16 candle-power each, site and buildings at £11,900. The annual cost of production of which would be £3,300 to £3,700. Mr. Norman, in opening the discussion, pointed out that the Corporation had already affirmed the desirability of the introduction of the light, and moved the adoption of the report. Alderman Griffith seconded the motion, and characterised the system of electric lighting as one calculated to benefit the trading interest and give impetus to the town. The committee's report was then adopted by 11 to 4. It empowers the committee to proceed with the matter, and procure tenders to be submitted to the council.

Electric Lighting of Stratford-on-Avon Church.—A proposal has been made for lighting by electricity Stratford-on-Avon parish church. The vicar announced to the congregation on Sunday night that such a project had been his ambition ever since he came to Stratford, and hoped very soon it would be realised.

The Ice Carnival.—The International Ice Carnival at the Albert Hall opened on Thursday, and extending over three days, has been gratuitously lighted by Messrs. Laing, Wharton and Down, of New Bond Street, who have provided 18 Thomson-Houston arc lamps, of 1,200 C.P. each, driven from the existing engines in the basement of the building. This firm, it may be remembered, carried out the lighting of the American and Italian Exhibitions at Earl's Court in 1887 and 1888. In addition to this installation at the Albert Hall, there were a large number of incandescent lamps supplied, with the necessary energy by the plant already fitted on the premises. Messrs. M. Immisch & Co., of Kentish Town, exhibited a facsimile of an electric carriage built for the Sultan of Turkey. The original of this is the second vehicle of the kind supplied by this firm, but there are important differences between the first and the second carriage. The apparatus for this four-seat vehicle consists of 30 cells, E.P.S. type, capable of being coupled in parallel or in series by means of a switch, so as to give as large a variation of speed as possible. The gearing involves a countershaft driven by spur gearing very finely cut, and this countershaft has balanced gear to enable the trap to turn sharp curves easily and safely. The motor is one of Immisch's 1-H.P. type, running at 2,000 revolutions per minute for a speed of 10 miles an hour. At this speed one charge will suffice for four hours, *i.e.*, 40 miles. The carriage can be run at a higher speed than 10 miles an hour under favourable conditions as to road, and can be pulled up almost within its own length.

Telephonic Facilities of Glasgow.—By arrangements with the National Telephone Company, subscribers to the Glasgow Royal Exchange will in future be able to use the telephone free of charge.

Cable Rates to South America.—A petition promoted by the *South American Journal*, and signed by representatives of many other newspapers in this country, in other parts of Europe, and in South America, is being prepared for presentation to the South American cable companies, urging a reduction of Press rates. Such a reduction has been made by the Eastern Telegraph Company and the Atlantic companies, and it is believed that the prayer of this petition will be granted. The editors of the *South American Journal* (Dashwood House, E.C.) invite the co-operation of newspapers and the public generally.

The Submarine Telegraph Company.—Mr. Pinkerton asked the Postmaster-General whether the staff of the Submarine Cable Company were to be placed upon the established staff of the Central Telegraph Office, and, if so, as the maximum of a telegraphist in the submarine service was £150 per annum, whether the submarine officers in receipt of their maximum would be placed upon the minimum scale of the senior clerks of the Central Telegraph Office (£150 to £190), to the detriment of the telegraphists of the first class of the Central Telegraph Office, many of whom had already been waiting two years for promotion from the maximum of their class (£140); and whether he would take such steps as would prevent any injustice being done to officers who had been many years on the establishment. Mr. Raikes: In reply to the hon. member, all I can say is that in any arrangements that may be made for the transfer to the Post Office of the staff of the Submarine Telegraph Company care will be taken to prevent injustice being done to officers already in the service of the department.

The Forth Telegraph Cables.—Telegraphic communication in the Forth district has been somewhat interrupted of late by the breakdown of the submarine cable which crosses the Forth between Burntisland and Granton. This has necessitated a visit from the Government cable steamer *Monarch*, which is now in the Forth, and is engaged in repairing the old and laying a new cable.

The Director-General of Indian Telegraphs.—Mr. D. Sullivan asked the Under-Secretary for India, on Monday, when Sir Albert Cappel, who completed his five years' tenure of office as Director-General of Telegraphs on the 14th of June, 1888, would be required to vacate that appointment; and whether Colonel Mallock, the officiating Director-General, would revert to military duty on attaining the age of 55 years next April, in accordance with the usual practice. Sir. J. Gorst: Sir Albert Cappel, who is on leave, will vacate his appointment in March, 1890, up to which date he is entitled to furlough. Colonel Mallock will vacate his appointment in April, 1890.

Iron and Copper Telegraph Wires.—Answering a question put by Mr. H. Gardner in the House of Commons, Mr. Raikes said: So long as the difference in the price between copper and iron wire is so large, the Post Office, in erecting new wires, must make use of iron. There has been no intention of generally replacing iron wire by copper.

The Channel Cables.—A Dover correspondent says that Government officials are now engaged at Dover, Calais, and Ostend in making final examination of the cables of the Submarine Cable Company preparatory to taking them over on the 1st of April. Instructions have been received by the captain of the telegraph ship, *Lady Carmichael*, at Dover, that after the 1st of April she will be stationed at Woolwich.

Opening of a Telephone Exchange.—A telephone exchange was opened in Burton-upon-Trent last month. There was a large attendance, and the Mayor presided. Congratulatory messages were received by him from the Mayors of Birmingham, Wolverhampton, Walsall, Sheffield, and Nottingham. The Mayor thanked those present for their attendance, and expressed a belief that the establishment of a telephone exchange in the town would confer a boon upon the inhabitants. He afterwards declared the exchange open.

Electric Meter Competition in Paris.—The following are the terms of the electric meter competition, which is to take place under the auspices of the Paris Municipal Council: 1. The instruments submitted to the committee may be either for continuous or alternating currents. Generally speaking, every instrument will be admissible which is intended to measure electric energy under any form whatever. 2. The competitors may suppose that only the difference of potential or the strength of the current is varied, or that both are varied. They may, therefore, send in ampère-hour meters, volt-hour meters, or watt-hour meters. 3. The meters must, above all, be suited to a small consumption; they ought to be able to measure the energy furnished to a single 10-candle power lamp. 4. For alternating currents the same conditions hold good; but attention should especially be given to the construction of watt-hour meters, which alone give exact results in inductive circuits. 5. The instruments will be submitted to comparative tests as to (*a*) proportionality and accuracy at every output; (*b*) the energy wasted in effecting the measurements; (*c*) the disturbance caused by using the instruments; (*d*) the practical value of the instruments (simplicity, cost, regulation). The five members of the jury appointed by the Municipality are MM. Mascart, Hospitalier, Vaillant, Lyon-Allemand, and Pottier.

Institution of Electrical Engineers, Students' Meeting.—A meeting was held on Friday, March 8th, at 8 p.m. Mr. Guy C. Fricker, A.I.E.E., in the chair. The discussion on Mr. H. W. Handcock's paper on "Ship Lighting and the aspects of Electrical Industries in the Colonies," was opened by Mr. Rance, Junr., and continued by the chairman and Messrs. G. Müller and Childs. Mr. Handcock replied, and a vote of thanks to Mr. Fricker for presiding terminated the proceedings.

Electric Lighting in Scotland.—During the past three months the following installations have been fitted out with Rankin Kennedy's complete ship lighting system: ss. *Le Flandre* and ss. *Phosphor* for Sir W. Armstrong, Mitchell & Co., Newcastle; ss. dredger *Preston* and ss. *Singapore*, for Messrs. Fleming and Ferguson, Paisley; ss. *Kaveri* for Messrs. Dunsmuir and Jackson, Glasgow. Also a complete installation in the boot and shoe factory of Messrs. Clark & Kilmarnock, who also employ a Kennedy motor, driven electrically, for the sewing machine department of the works.

Electrical Exhibition at St. Louis.—The directors of the St. Louis Exposition and Music Hall Association are making arrangements for an extensive general electrical exhibition, to be held at St. Louis, Mo., U.S.A., commencing September 4th, 1889, and continuing for a period of six weeks. It has been decided in reference to electrical exhibits from abroad that ample accomodation shall be reserved and no charges shall be made for either power required, or space occupied. Such exhibits will be under the care of the General Manager, without charge to exhibitors. Arrangements are pending for the reduction of freight charges to one half the usual rates.

Re-organisation.—Messrs. Mix & Genest, of Berlin, inform us that they have sold their establishment to a group of banking firms for the purpose of transforming the same into a company, the rapid development of their business having rendered this necessary.

Edison's Incandescent Lamp Patents in Canada.—A telegram from Ottawa, dated March 8th, states that the Commissioner of the Patent Office gave his decision today in the cases arising from the Edison incandescent patent in Canada. He cancelled the patent on the ground of illegality, and not being manufactured in Canada, according to the provisions of the statute.

The Birmingham Electrical and Industrial Exhibition.—The preliminary arrangements for the electrical and industrial exhibition, which is to be held in Bingley Hall, Birmingham, in August, September, and October, are making satisfactory progress. Most of the principal electrical firms in the country will be exhibitors. Allotments of space will be made in about a month from now, but some time has yet to elapse before the period of receiving applications for space is brought to a close. The committee has decided that the lighting and transmission of power for the use of the hall shall be distributed among twelve of the exhibitors, and it is also arranged that medals or other prizes shall be awarded to the exhibitors generally for the best systems of electric lighting. The work of adjudicating upon the merits of these systems will be entrusted to gentlemen of the highest eminence in the electrical world, amongst them being Sir William Thomson, Sir H. Roscoe, M.P., Sir David Salomons, and Prof. Silvanus P. Thompson. The electrical section will be divided into three departments, namely, lighting and transmission of power; secondly, dynamos, lamps, motors, electroliers; and, thirdly, telegraph and telephone apparatus, phonographs, electric bells, and various kinds of electric machinery.

Heavy Insulation.—We hear that one of the large cable companies has received an order for one mile of underground cable, to be insulated with half-an-inch covering of India-rubber, laid on in about twenty layers, the price being approximately £3,500 per mile.

The Royal Society.—Amongst the papers down to be read at Thursday's meeting were the following, by Dr. Gore, F.R.S.:—1. "A Method of Examining the Rate of Chemical Change of Aqueous Solutions." 2. "Relative Amounts of Voltaic Energy of Dissolved Chemical Compounds."

The Commissioners of Sewers and the Central Subway.—The Commission had decided to petition Parliament against the London Central (Subway) Railway Bill. It was not actually opposed to the scheme, but it wanted to obtain a *locus standi* to enable it to have a voice in moulding the measure in the interest of the ratepayers. The petition was brought up at the last meeting by the Remembrancer, and, according to the *Citizen*, a short, sharp, rhapsodical discussion followed as to whether the paper was to be signed or not. The statement contained just such a complete resistance to the Bill as there might be in the brief of a prosecuting lawyer: everything painted as black as it possibly could be. According to the petition, the scheme was unnecessary and uncalled for; it was most speculative, and the electric motors and all the arrangements whatsoever were incomplete and were radically bad in every iota. Even electricity itself was not brought to that perfection, as a science, which was demanded by such a scheme as that; the railway would be a competitor with the omnibuses. All this rather pleased some of the opponents of the measure, but others objected to the petition just as vehemently as the petition objected to the Bill. The Remembrancer attempted to throw oil on the troubled waters by explaining that that was the proper way of securing a *locus standi*. Mr. R. Stapley said the objections were all of that antiquated type which were made to all improvements for the public good; the petition made statements which it did not attempt to verify. The Remembrancer: "We don't use arguments; we simply state the case, and we know that the company must prove to the contrary." Mr. H. N. G. Dann saw in the electric tramways of Paris and Brussels a reflection upon the proverbial enterprise of the Londoner, who had not yet adopted the new system of locomotion; and Mr. A. C. Morton referred to the objections made to the scheme from the omnibus proprietors' point of view by exclaiming, "surely it is no part of the Commission to object to competition." Mr. J. Judd remarked that unless they got a *locus standi* they would be unable to defend themselves against those things named in the petition; and the inference brought to his feet Mr. Deputy Scott, who contended that the petition quixotically defended people who were already defended by the Act. The Commission ought not to appear as an opponent to this great work. Mr. H. H. Bridgman greeted the subway system as a means whereby their thoroughfares would be relieved of their traffic-congestion. Mr. Morton trusted, if the railway was constructed, that the tradespeople would be compensated; it had been the rule to compensate large freeholders and to allow tradesmen to be ruined. Mr. W. P. Treloar and Mr. G. Shaw spoke upon the matter, and it was decided that the petition should be signed, only four votes being recorded to the contrary.

Sick and Accident Fund for Workpeople.—Most large works have probably some method of insurance against accident and sickness in vogue amongst the workpeople, but perhaps all are not so satisfactory as that carried out by the *employés* of Messrs. Thos. Fletcher & Co., the well known manufacturers of gas heating appliances, of Warrington. Messrs. Fletcher think so highly of their plan that they are anxious to see it put in practice by other firms, and are willing to supply information to those desiring it.

Business Transfer.—Mr. G. E. Pritchett, who has for some time past run a central station at Rathbone Place, Oxford Street, has disposed of his business to the Metropolitan Electric Supply Company, Limited.

Metropolitan Railway Bill.—This Bill, which empowers the company to use electricity as a motive power and to enable them to run over the Aylesbury and Buckingham Railway, passed the Examiner upon Standing Orders in the House of Commons on Monday.

Electric Lamps Stolen.—A writer in the Glasgow *Evening Times* says: I am told that 17 electric lamps have been stolen on the Underground Railway since the New Year—all from first-class carriages.

Siemens's Morse Writing Apparatus.—The following letter has reached us from a gentleman whom we recognise as an old student at the Glasgow and West of Scotland Technical College. We mention this only because his last paragraph does not appear to be directly connected with the subject he discusses:—"In your issue of 5th March there is a notice of a modified system of recording Morse signals. Strictly speaking, this modified system is *not* one of the vertical signs, as you call it, but is one in which the essential feature is the reduction of the normal length of the Morse dot and dash by about one-half. At the same time, the depth of the mark across the paper is greatly increased, for what practical reason is not quite clear, since this increased depth in no way serves to distinguish between dot and dash signals: in fact, the expedient seems to 'drown' the otherwise obvious distinctiveness of the signals. Let any of your readers lay the edge of a sheet of notepaper across the series of modified marks in your paper, so as to present to view only about one-sixth of their printed depth, and it will be observed that the marks as thus shown are much more readable than when they appear in full depth. Legibility is the primary consideration. Economy of paper is altogether a matter of secondary consequence, and under present circumstances it could easily be attained by simply reducing the dimensions of the ink-wheel, and the speed at which the paper runs. Moreover, the key-speed Morse printer is quite obsolete, in both this country and the United States, so that there is really little room for the adoption of the modified system. I would add, in conclusion, that I here confine myself to simple unexaggerated criticism, as I have no inclination whatever to imitate the questionable rhetoric which, in the issue above referred to, is employed in your editorial columns in criticising Prof. Jamieson, Mr. Kapp, and others.—TELEGRAPH."

University Extension Lectures.—The course of three lectures being delivered by Mr. W. Lant Carpenter at the Polytechnic, on "Electricity in the Service of Man," is proving very successful. The audiences at the first two of the series have been about 1,250; and hundreds more have tried but failed to obtain admission.

NEW COMPANY REGISTERED.

Priestman Brothers, Limited.—Capital: £150,000 in £10 shares. Objects: To take over the business of Priestman Brothers, of Hull and London, and generally to carry on business as mechanical engineers, iron-founders, engine builders, and of makers and dealers in electric and motive power and lighting. Signatories (with 1 share each): *W. D. Priestman, *S. Priestman, Edgar Priestman, Holderness Foundry, Hull; *Joshua Priestman, 73A, Queen Victoria Street; Thomas Priestman and Albert Priestman, Temple Buildings, Hull; Edmund Priestman, Sheffield. The signatories denoted by an asterisk are first directors. Qualification: £1,000 in shares or stock. Registered 6th inst. by Williamson, Hill & Co., 13, Sherborne Lane, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Railway Automatic Electric Light Company, Limited.—An agreement of 7th inst. (filed 9th inst.), confirms the provisional purchase agreement, dated 14th, and discharges Mr. Wm. Henry Eagland from all liability in connection therewith. Registered office, 5, South Parade, Leeds.

Byng Telephone Company, Limited.—The annual return of this company, made up to the 25th ult., was filed on the 8th inst. The nominal capital is £5,000 in £10 shares. 207 shares have been taken up, and £8 per share has been called and paid thereon, the paid up capital thus amounting to £1,656. Registered office, St. Nicholas Chambers, Amen Corner, Newcastle-on-Tyne.

CITY NOTES, REPORTS, MEETINGS, &c.

Anglo-American Brush Electric Light Corporation, Limited.

THE eight ordinary general meeting of this company was held at the Cannon Street Hotel, on Wednesday, the Right Hon. Lord Thurlow, F.R.S., presiding.

The directors' report for the year was printed in the REVIEW last week. This report having been taken as read,

The Chairman said: I will now proceed, without further loss of time, to say a few words, as is customary, on these occasions, explanatory of the terms of the report, and of the figures which are contained in the balance-sheet. I think, however, on the present occasion, that the report is so full and exhaustive, and the figures so satisfactory, that it will not be necessary for me to detain you very long, at this stage of the proceedings at any rate. At a later stage we shall be happy to give you any explanations on any points that you may very naturally raise, and desire further information upon. But I am bound to say that contrasting this report and balance-sheet with those of previous years, I think it will be difficult for any shareholder to entertain any other than feelings of satisfaction and hopefulness for the future. This has undoubtedly been a year of progress, very marked progress, in all electrical affairs. To what extent that improvement is due to the Act of Parliament that was passed last Session, you must each of you judge for yourselves. My own impression is, that the advance in electrical science, and in its application to domestic affairs in almost every shape and form, is due to a very large extent to the passing of that Act of last year—amending Mr. Chamberlain's well-known Act of 1882; and I am glad to be able to say that I believe Mr. Chamberlain himself heartily approves of the action of Parliament last year, and recognises the advantages that have ensued from it. Well, gentlemen, that being so, I think I need not detain you at much greater length upon that point, but it may be interesting to you to know that there are at the present moment no less than 21 central stations established or in course of progress in the metropolis alone. You all know that in every considerable town in England the same thing is taking place; and not only in every considerable town, but in many second and third class towns, and almost villages. Well, in a very large number of these enterprises we are concerned, not merely as manufacturers, but in other ways. Under our articles we are, as you know, entitled to participate in this kind of undertaking, and although we proceed with the greatest possible caution, we deem that it is advisable, and for your interests, which are identical with our own, to embark occasionally and assist in these various local enterprises. There is one, for example, which I desire to mention, in which we are embarked, and in which we are taking the very greatest interest, and in which some of your directors are directors of the company, and which, I am thankful to say, is making very rapid and satisfactory progress. I allude to the Chelsea Electricity Supply Company. We are now building—in fact it is almost completed—a central lighting station in Chelsea; we have a large area to supply, and favourable contracts, not only with consumers, but with joint manufacturers, those who are manufacturing jointly with ourselves. I venture to think that that company will be a model in every way; it will be followed very largely by those stations which are established hereafter. We have proceeded with the very greatest care in the consideration of all the details requisite for that undertaking. Of course central lighting installations and stations are still to a certain extent matters of novelty. A certain amount of experience has undoubtedly been gained, but a great deal also undoubtedly remains to be done in the way of ascertaining what is ultimately the best kind of building, the best type of machinery, engines, and a thousand other matters. But I repeat that that station will be a model of what such a station ought to be, and will give general satisfaction to the large area which it will shortly light. At Bournemouth we proceeded with a different system. At Chelsea the system that we have adopted is that of underground mains and accumulators: at Bournemouth the system is principally by alternating currents and overhead mains, which, of course, in a comparatively rural district like Bournemouth, being more economical, has very great advantages; the distance is long, perhaps, and the lighting not very continuous. These may be considered, and justly considered, as rival systems of lighting. They both are receiving our attention. We have plant specially designed and manufactured in our own works which is adapted to both these systems, and I think I can say without fear of contradiction, that there is no company in London or on the Continent that can supply more efficient plant than can we from the Belvedere Road Works. I think, before I turn to the figures, about which I, of course, desire to say something, I should make some allusion, however passing, and however unwillingly—I do not like to discuss matters before the Law Courts; still I feel that you will expect me to say something about pending litigation. Litigation is a very important matter. I am quite sure it has never been absent from our minds during the past 12 months. At the same time, you must not overlook the fact that the exact character of that litigation is not so important to us as to our antagonists. What we have at stake represents barely one-tenth of our business. What the Edison-Swan people have at stake represents the whole of their business; at any rate, there is a monopoly. Therefore, I say we can regard this matter with more calmness perhaps than our antagonists. It is not a matter of vital importance to us; we can get on without making lamps. We have a very large business other than this, a business which is increasing by leaps and bounds, and which in the course of eighteen months or two years will surprise you all. I, myself, and I think I might speak for my colleagues, regard this litigation without any anxiety, without reference to any possible result. Well, there is another reason why we can regard that litigation without overwhelming anxiety, and that is that we are confident in the justice of our cause, and we have very considerable confidence in the final issue. Of course litigation is an unpleasant thing to be connected with, and I can only say from my own experience that it is a thing I am absolutely unacquainted with. I have always made terms in any matters personal to myself with any gentlemen who have attempted in any way to get me into litigation, and I should always pursue the same course in affairs connected with any company in which I happened to have a voice. But the present occasion is an exceptional one. We were met by people who contested the value of the patents for which you paid very large sums. We could not act according to what might have been our desires and wishes if it had been a private matter. We took the opinion of the first counsel, and that opinion was that we had a good case and ought to fight it to the utmost. We have fought it, and the result has been one way in one court and the other way in the other. We are now in a state of see-saw. The uncertainty of the law is proverbial, and it is well exemplified in this case. The judgment of Mr. Justice Kay was considered at the time a very powerful decision: that went to appeal and was reversed. We have now notified our intention of taking it to the House of Lords, which is the highest Court of Appeal in the country. I do not know whether even the House of Lords need be absolutely final, for reasons which I need not enter into. At any rate we have resolved to stick to our guns. At the same time, as I mentioned just now, my own personal feelings are always in favour of making terms with enemies, and this board has never neglected an opportunity of approaching the opposite side in a conciliatory spirit, and with every desire to meet them half-way, or as fully as any gentleman in this room could wish. I am bound to say our antagonists have not shown the same conciliatory feeling. On the contrary, they have manifested a desire to continue this suit and to really put us, if one may use the expression, to every inconvenience in their power. That may be all right and justified in a thing of this sort. As I said before, their position being different from ours, the suit being a vital one to them, it is hardly possible for them to approach it with the same calmness and independence as we can ourselves. However, I can assure you that while we have deemed it our duty to take this matter to the House of Lords, still we are open to be approached by the Edison-Swan people at any moment. We are willing to make terms with them to save your interests and to save your honour in any reasonable way that can be suggested, and I am not without hopes that, before the interval which must elapse before this case can be heard in the House of Lords, something may be done in the way of arriving at a conclusion satisfactory to both parties. Beyond that I think I need say very little on that point. We have one other case pending at present, a case against Messrs. King, Brown & Co., of Edinburgh, with reference to compound winding. We claim to have the controlling patents for compound winding dynamos. This is admitted by all English firms, and they are paying a royalty which mounts up to a nice little sum during the continuance of the patents. The only firm which has contested our rights is that of King, Brown & Co., and as that case is still pending I need say no more. Now, I think you will permit me to turn to the accounts, which are as satisfactory as the report; indeed, one cannot be satisfactory without the other. You will have noticed that this report has been accompanied in its transmission to the shareholders by a diagram, which is somewhat unusual, but we considered that it was perhaps the readiest way of bringing the facts to the comprehension of the shareholders, to show to what extent the volume of business has increased, to what extent the gross profits have increased, and to what extent the general charges have, I am glad to say, decreased or remained stationary. This is a remarkable document. In five years the volume of business increased from 100 to 307, or over 200 per cent. in five years. In the same year the gross profits have increased 243 per cent. That, I think, is very remarkable, and I think that I can fairly challenge any other electric light company in the world to show similar results. We still have one strong feature to dwell upon, and that is that the general charges have increased hardly at all. That can only be due to one thing, to improved management and economies introduced by our able general manager, Mr. Garcke, in every branch of administration. Turning to profit and loss account, you will see that the gross profit on this year's transactions reaches the very respectable sum of £28,049. I think that is very satisfactory. To this we have to add, balance carried forward from last year, £2,500, making an available balance of £30,612 to carry to general account. You will see on the other side the standing charges. I have referred to them already, generally; but I think I ought to point out that the standing charges show only an increase of 7 per cent. in themselves, whilst the business itself has increased 50 per cent. during the last 12 months. Those are figures I should like you to bear in your minds. Turning to the balance sheet, you see that the share capital has been increased by the issue of 1,160 new shares. Those shares were issued for the purpose of increasing our working capital, which, as I think you may well imagine, we had every desire to do by every legitimate means, to enable us to undertake the large contracts which are daily being placed before us, and which we are naturally loth to send away to swell the volume of business of our competitors in the trade. When I speak of our competitors in the trade I think it may be interesting to you to know that we have not had it all to ourselves, this prosperity, this increasing prosperity, in electrical business. If you consult "The Electricians' Directory," you will find that in 1883 there were only 57 electrical engineers carrying on business in this country. In 1885 they had increased to 101, in 1887 to 156, and in the last number, that for 1888, you will find 260. In six years the number of these gentlemen carrying on business as contractors in the electric lighting business has increased from 57 to 260. Most of these are in London, but the difference between London and the country is not material, for a large number of the country houses have their London establishments. So the competition has been very severe, and no doubt it will be increasingly severe; but when you regard what we have been able to do during the last 12 months, I think you need not despair of our holding our own in the future of this industry. Then, if you turn to the creditor account of the balance sheet, you will find the patents practically stand at the same figure. It has been slightly raised by additional patents which it has been our duty to take out, and by the payment of certain costs and charges incidental to their upkeep and maintenance and making the patents more valuable. From time to time it is possible to improve patents, to continue their lines, and so on, by expending a very small sum of money; or we may purchase incidental or supplemental patents. Of course, we should be neglecting our interests if we failed to avail ourselves of these opportunities. I said last year I considered these patents stood at a low figure in our books, and, as I said just now, that I challenged any electric lighting company to show so good a diagram as ours, so also I challenge any electric lighting company to show patents of equal value standing at so low a figure. I do not know that I need deal fully with the other accounts. Property and stock have been properly valued and stand at fair figures. We are owed for work done over £46,000, after deducting a certain margin for what are called bad debts, but which, I am bound to say, we do not look upon as bad debts. The present position of the debtor balance is that we have £48,531 due to us, whereas we only owe to creditors, tradespeople, and others, £22,120. That is a highly satisfactory state of affairs. Then there is a suspense account as a provision against the expenses of litigation. We considered how to deal with these expenses, and we consulted with our auditors and legal advisers. It would be manifestly unfair to put them, while the cases are still *sub judice*, to profit and loss account; they may turn out to be largely, if not entirely, on the other side. There is an element of uncertainty about the item which quite justifies its being dealt with in this way. Against it, however, on the other side, you will see a provision amounting to £17,816, which will be sufficient for the purpose should the worst come to the worst. That provision account is not represented wholly by money in the bank. At the present moment it is employed in our business; it is represented partly by stock, partly by plant, partly by some of these debtor balances due from our customers. It is a satisfactory feature in our accounts that we have that provision, supposing our anticipations are not fulfilled. I do not know that I need trouble you at the present stage of the proceedings with any further remarks, except to say that I consider that the result that has been achieved has been achieved by the continuous and united efforts, all in the same direction, of enhanced efficiency combined with economy, not only of the members of the board, some of whom take the greatest interest in and have the greatest technical knowledge of all your affairs and of everything that transpires in these manufactures, but also of your general manager (Mr. Garcke), your usperintendent engineer (Mr. Raworth), your electrician (Mr. Percy Sellon), your other electrician (Mr. Mordey), and your factory manager (Mr. Sillar). To every one of these gentlemen, in their respective offices, your thanks are due for the result which has been achieved. You stand to-day with a realised profit, available to pay, if you choose to take it, a 5 per cent. dividend on the whole of the share capital of this company. It remains for you to decide this morning what you will do with that balance—whether you will put it in your pockets as a 5 per cent. dividend for the twelve months, or whether you will take the more prudent course, which we undoubtedly recommend, of leaving that in abeyance until litigation is over. I have no doubt in my own mind that that is the wiser course to pursue. It is the course that has been pursued by our opponents, the Edison and Swan Company. They had a large balance of profit on their last year's working, but did not distribute it among their members. They have kept it in the bank to meet eventualities. I think it would be unwise for us not to take the same prudent course; but if you should differ from the feeling of the board on this point, it is undoubtedly within your competence at the present moment to elect to take that as dividend, and to divide the profit of £12,885 which stands to your credit on this year's balance sheet. Then I have only one thing more to say, and that is that this business is increasing, and increasing very rapidly. I consider we have overcome the difficulties of manufacture. We have undoubtedly further improvements and economies to effect. It is impossible to go on manufacturing from day to day without perceiving opportunities of manufacturing under more economical circumstances. We might follow the example of some of our friends, and take our works into the country, where labour and coals and other matters are undoubtedly considerably cheaper. Then there would be the expense of moving, and other things. We may pursue that course a little later; for the present we are satisfied to remain where we are, because, while there are some of those drawbacks to which I have alluded in carrying on a manufacturing business in London, there are incidental advantages. When strangers, especially from foreign countries and the colonies—with which we do a very large business—come to London, it is a satisfaction to them to be able to see our works, to see the class of plant and machinery we have, and in some cases we supply plant and machinery to some of our colonial customers; and it is much more convenient—and, I believe, in many cases much more remunerative—to be able to show it to them on the ground than to take them into the provinces to see it. I feel sure that by having our works in London we get orders, and very many of them large orders, which we would not obtain if they were situated a hundred or a couple of hundred miles from London. For these reasons a move into the Midlands or elsewhere is not to be too lightly undertaken; but it is a matter we have been carefully considering, and will continue to consider, and there is no doubt that if it were done large economies would ultimately ensue. Well, what I was going to say was this—our business is increasing; it is quite necessary that our capital should increase in a corresponding manner. We have got every shilling in the business now that we are able to put into it; we have got a provision account in it of £17,816; we have got a certain amount of that £12,855 in it, although we had nearly £10,000, as you see, at the bankers' on that date (December 31st). Of course, you may say we owe our creditors £22,000. It might be possible, of course, to increase that, and carry on a large business with still greater liabilities; but you know what that means—you do not get your discount on cash payments. It is necessary to avail ourselves of all these kinds of advantages; therefore, I say that to carry on this business remuneratively in the future, and to be able to watch its growth with equanimity, and derive the greatest possible advantages from it, it will be necessary for us and for you, sooner or later, to largely increase our capital. There is another reason why that is necessary. Look at these other companies that are doing business in the same way. Look at two or three of these lighting companies that have been recently formed in London, with their millions of capital—the London Electric Supply Corporation, and one or two others that I need not mention. You know the amount of money they go to work with—a million or two millions of capital—and they have the means of raising that capital. Undoubtedly, if we are to compete on fair and equal terms with these other gentlemen, in course of time we must have our millions too. We have not seen this thing grow without seeing the necessity that would naturally come to us if it is proved that the business is a profitable one. We have now proved that the business is a profitable one—we have proved that to a greater extent than any of our competitors, and I feel confident that when the time comes, as I believe it will before very long, that we go to the public for a large increase of capital, that attempt on our part will be met by a most willing response from London and the provinces, by gentlemen who have money to invest, and take an interest in this new and increasing industry. Gentlemen, I have nothing to add to what I have said; but I have to thank you, before I sit down, for your continued confidence in myself and the board with which I have the honour to be associated. I can only say that we will continue, to the best of our abilities, to work for you, and we hope to justify the continuance of the confidence which has hitherto been extended to us, and without which I feel, for one, it would have been impossible for us to have brought this business to the satisfactory position that it now occupies. I therefore, gentlemen, beg to move: "That the report of the directors and the statement of accounts up to December 31st, 1888, now presented to the shareholders, be received and the same be hereby adopted."

Mr. J. S. Sellon briefly seconded the resolution, remarking that the shareholders must have come to the conclusion that a real and substantial improvement had now taken place in the prospects of the electric lighting industry. So far as the corporation was concerned, it was certainly not in the rear of these improvements.

Mr. Weir, Mr. Currie and other shareholders congratulated the directors on the improved state of affairs, and put a few questions on matters of detail.

The Chairman, replying to the shareholders' remarks, said the compound-winding royalties appeared in the accounts, but it would not be wise to state their exact amount. They had very great hopes that they would prove a substantial source of revenue during the remainder of the life of the patents. It was necessary that they should have a large amount of stock on hand, but it was less this year in proportion to the volume of business than last. They had done a large amount of exhibition lighting at Melbourne, Glasgow, Manchester, Barcelona, and other places. They anticipate a considerable slice of the Paris Exhibition this year; indeed, they already had the contracts. These things made it necessary for them to have a considerable amount of stock. But that which went out to the colonies and elsewhere very seldom came back again. In the case of the Melbourne Exhibition he should not be surprised if none of the plant came back; and the same with regard to Barcelona. The appeal might come on in the House of Lords in the course of four or five months, or it might not for 12 months; it was impossible to say.

The resolution was put and unanimously carried, as were subsequent resolutions for the re-election of the Right Hon. Lord Thurlow and Colonel Steuart as directors, and of Messrs. Cooper Brothers as auditors.

A vote of thanks to and confidence in the directors and officers terminated the proceedings.

The Direct Spanish Telegraph Company, Limited.

THE report of the directors for the half-year ended 31st December, 1888, states that the accounts for the half-year show, after providing for debenture interest, a balance to the credit of profit and loss of £5,720 4s. 10d. The traffic receipts show a decrease of £305 4s. 11d. as compared with the corresponding half-year of 1887. The falling off in the receipts for last half-year is attributable to the slackness of the fruit trade owing to the inferior crop of last year in Spain.

The working expenses are £95 12s. 11d. less than in the corresponding period of last year.

The company's cables and the land lines in connection with them have continued in good working order throughout the half-year. Unfortunately since the expiration of the half-year for which the accounts are now submitted an interruption of the Bilbao cable has taken place; the cable was, however, speedily restored and has worked well since. The directors propose that the cost of these repairs (£2,966 10s. 7d.) shall be charged partly to the reserve fund and partly to revenue.

After putting £2,500 of the balance of profit and loss to the reserve fund, which amounts to £13,660, there remains an available balance of £3,220 4s. 10d. Out of this amount the directors recommend the payment of the dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend at the rate of 4 per cent. per annum (free of income tax) on the ordinary shares, making with the previous distribution 4½ per cent. for the year 1888, against 4 per cent. in the year 1887. This will admit of a sum of £723 5s. 3d. being brought forward to next account towards the payment of the portion of the cost of the repairs of the Bilbao cable charged to revenue. The dividend warrants will be issued on 1st April, 1889.

Sir James Anderson and Mr. Denison Pender are the directors retiring by rotation, and, being eligible, offer themselves for re-election. The auditor, Mr. Herbert R. Duke, retires, and offers himself for re-election.

Brazilian and Submarine Telegraph Company, Limited.—The directors have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended December 31st, 1888, and payable on the 25th inst. The books of the company will be closed from the 18th to the 23rd inst., both days inclusive.

Western and Brazilian Telegraph Company, Limited.—The directors have called a special meeting of the shareholders for the 19th inst., for the purpose of ratifying an agreement made between the company and the Brazilian Submarine Telegraph Company, Limited, in respect of the working of the lines of the two companies and the division of the traffic receipts thereof.

Oriental Telephone Company, Limited.—A dividend of 3 per cent. is announced for the past year by the directors of this company, and, after placing £2,500 to the reserve and writing off the balance of the preliminary expenses, viz., £3,000, a surplus will remain of £500.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 8th, 1889, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,401.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ended March 8th amounted to £5,575.

UNDERGROUND CONDUITS AND CONDUCTORS.[*]

AT the eighth meeting of the National Electric Light Association, held in New York, on August 29th, 30th and 31st, 1888, the following resolution was offered and adopted:—

Resolved: That a committee of five be appointed by the Chair, to examine into and report upon the systems of underground conduits, with underground conductors and conduits now in operation, and the number of wires actually in use in these conduits, and to report at the next meeting of this association.

The president appointed Messrs. Lynch, Barney, Kerr, Davis, and Crocker, as members of that committee. And as chairman of that committee, I beg leave to submit to the association the following report:—

As the resolution called for a compilation of all data connected with the actual placing of electrical wires underground, your committee deemed it advisable to send out a circular, calling upon and asking all the local electric light companies for the results of any practical tests that they had made.

To carry out this idea, they caused to be printed the following circular:—

GENTLEMEN: A committee was appointed at the semi-annual convention of the National Electric Light Association, held in New York, August 29th, 30th, and 31st, to investigate and collect all data relating to underground wires and conductors, both in this country and Europe. It is the intention of this committee to present this report at the Chicago Convention of this association, which will be held on February 19th, 20th, and 21st, 1889.

So many erroneous statements have been made from time to time regarding experiments or tests with underground wiring that the committee (in order that it may hear both sides of the question) feels that it is necessary to obtain all of the most important details and facts regarding this subject.

Will you therefore kindly answer, as far as may be in your power, the following questions, and return the same to the headquarters of the association as soon as possible. Your answers to these questions will be looked upon as confidential, and will not be referred to by name or locality in the report of the committee. It is desirable that you send in your answers at once, as the compilation of statistics takes time.

EUGENE T. LYNCH, *Chairman.*
ALLAN V. GARRATT, *Secretary.*

1. Have you ever placed underground any electric light conductors carrying currents at a potential of 1,000 volts or over?
2. If so, state the number of experiments, giving the date of each?
3. What was the length of each individual conductor laid underground?
4. What was the voltage on each conductor?
5. What was the current, in ampères, carried by each conductor?
6. What make and style of dynamo supplied the current on each of these conductors?
7. Were these conductors single or grouped in cables?
8. How many conductors to the cable?
9. What was the size of the conductors used (in answering this question give the number and gauge)?
10. What was the thickness of the insulation?
11. Who was the maker of the cable?
12. Were the cables laid in any form of conduit?
13. If so, what kind of conduit was used?
14. Describe the manner in which the cables were laid in the conduit; whether drawn in, built in, or otherwise?
15. If the cables were laid directly in the ground, describe the method of laying them?
16. Was there more than one duct in the conduit?
17. If there were other ducts what was in them?
18. Did you have exclusive control of the conduit?
19. What was the total duration of your experiments?
20. Did the cables work satisfactorily during the entire time of your experiments?
21. If not, how long did they work satisfactorily?
22. If the cables failed to work satisfactorily, to which of the following causes do you attribute the difficulty? Please answer as fully as possible:—
    - *a.* Defective insulation?
    - *b.* Defects in joints?
    - *c.* Defects in making connections from cables to lamps?

Those were sent to all of the local electric light companies, and in response to them we have received 120 answers.

In presenting and compiling the answers to the various questions that were sent out, we have deemed it advisable to divide them into two classes, as follows:—Those who have had actual experience in placing and running underground electric wires, and, those who have not had actual experience, but whose opinions we have asked. Of the former class there are but seven. We will here give the details of the placing of the wires underground, the duration of tests, style of conduit used and the general results that were received in each of these seven answers. As it was stated in the circular sent out that all the communications would be regarded as strictly confidential, we have deemed it advisable that the names of the companies or individuals should not be mentioned in this report; consequently we will not refer to them by name.

FIRST: The writer has used the underground conductors for three years. Has used wire of three of the most prominent manufacturers. Has discarded two, and is now using the third.

The cables were carried in a cement pipe, and manholes were placed at every 250 feet. Cables had been drawn into the conduits, and, as a method of facilitating their drawing in, pulverised soapstone had been used for the purpose of avoiding abrasion.

Only one wire placed in each pipe.

He states that the wires have not worked satisfactorily, and that he has been compelled to shut down many times, that they are now running fairly well, but he is obliged to keep them under constant supervision and repair.

He accounts for most of the trouble that he has experienced, by defective insulation, defective mechanical construction, and by deterioration in the insulation in the wires, having had no serious trouble with the style of conduits that he has used.

In answer to the question, regarding the practicability of placing his conductors underground, he states: "We are operating some eight miles of underground wire; we wish there were less, and certainly are not anxious for more."

In answer to the question, regarding the difficulties and objections to underground wiring, and whether he considers them commercial, electrical, or mechanical, he states:—

Electrical.—There is no cable that will last with a current from a 50-light dynamo. Commercial.—Owing to the large cost of construction and expense of maintenance, and great possibility of breaks. There is consequently poor service and dissatisfaction. He has exclusive control of his conduit.

SECOND: The writer has made many experiments, in which he has used lengths of cable varying from 200 feet to two miles in length, manufactured by most of the prominent wiring companies. Cables have been laid in, and drawn in, his own conduits, conduits constructed both of wood and iron. The tests have usually been of short duration, and have been suspended in each case after a failure of the cable to work satisfactorily. The cause of the failure has been mainly defective insulation. Defective mechanical construction, defects in laying, defective conduits, injury to cables in laying or defective joints, have caused very little trouble, the main cause of trouble being in defective insulation and deterioration owing to the presence of gas, water, and steam.

His opinion, based upon the results brought out by the many tests that he has made, is, that he does not consider it practical, at the present time, to place conductors underground, the absence of insulation that would stand being the principal reason. If ever that question is settled, the cost would, in his estimation, make it commercially impracticable. In only one instance he had the exclusive control of the conduit.

THIRD: The company represented by the writer had four circuits underground for about one year. One style of cable only, manufactured by a prominent manufacturer, was alone used. The wire was drawn into a composition conduit, which had manholes at the corners.

Quite an amount of trouble was caused in the start-off by difficulty caused by abrasion to cable in drawing the wire into the conduit. The experiments were continued for one year. They caused a great deal of trouble with the lighting contracts, and at the end of that time were abandoned. He considers his chief troubles to be defective conduits, water in the conduits and deterioration of the cables, also, trouble in defective insulation, defects in joints, and trouble in making connections through iron pipes from the conduit to the surface.

His opinion, based upon the results of the tests that he has made, is: "That he does not consider it practicable to place his wires underground," and he states, "I do not know of any system that has yet proved satisfactory." And further states: "I know of no system to-day which, even at any expense, has proved satisfactory, except a system of subways built large enough for men to walk through their entire length."

In answer to the difficulties of placing wires underground, he states that he considers the difficulties to be commercial, electrical and mechanical in perfection, and still not be so expensive (in the end) as to make the commercial objection insurmountable. "We are all in the business simply to make money, and the commercial objection must be met just as much as any other." He did not have exclusive control of the conduit. The ordinance passed by the Common Council in his city in 1886, stated, "that their committee had examined the subject, and found the putting of all electrical wires underground feasible, and ordered all wires within a few months, and those outside of this district, underground within one year." He has been brought before the court a number of times on complaint of the City Attorney, but nothing yet has been done in the matter.

FOURTH: The writer has made two experiments during the last summer, one of which was a failure, and the other a partial success, though the duration of the second test, and the position it occupied in the circuit, was such as to give little importance to the result. The wires were pulled into a wooden conduit, there being two ducts in each conduit. Cables did not work satisfactorily He states that the failure is due entirely to defective insulation.

In answer to the question if he considers it practicable to place his conductors underground, he replies, "We do not, with any system known at present."

In answer to the last question, concerning the difficulties and objections to placing wires underground, he states: "The difficulty is particularly commercial, though I have seen no system which I think will properly insulate the conductors."

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[*] Report of committee of National Electric Light Association, read at Chicago meeting, February 20th, 1889.

FIFTH: The writer has placed two circuits underground, about the first of the present year. The cables used are those manufactured by six of the most prominent companies. They have been drawn into an asphalt conduit, 12 ducts in each conduit. The duration of his experiment has only been about a month and a half, and he states that it is too early to tell what will be considered the result of the experiment.

In answer to the question if it would be considered practicable to place the wires underground, he states: "Have seen nothing yet that will answer."

In answer to the question regarding his opinion concerning difficulties and objections to going underground, he replies: "Chiefly commercial, partly electrical and partly mechanical." He has exclusive control over his own style of conduit.

SIXTH: The writer has had wires in the conduits for about five years. The mains were carried through the streets in a composite system of conduits. The connections are made from the system to the cellars through iron pipes, and the wires are conveyed then through cellars, connection being made from the cellars to the houses. These cellars run completely around the block and permit of access to them for the purpose of repairing or making connections to wires.

He has used three different kinds of wires in the conduits, the cables now in use having been in position for about 13 months; although he has had trouble with them, he claims that satisfactory service can be maintained in his particular locality, and he considers the question of the distribution of power and light an exceedingly simple one in his city, which is probably the only city that is so fortunately situated.

He has in all about 32 circuits. He, states that he is on the right track regarding the placing of wires underground, and that the system such as he operates will run satisfactorily. The cables that he is using are guaranteed for three years. The trouble that he had with his first wires was mainly due, as far as he can ascertain, to the fact that the insulation surrounding the wires was not of sufficient thickness, and the main conduits themselves were not dry. He controls his own conduits exclusively.

SEVENTH: The writer has made some practical experiments and tests with cables under water; these were manufactured by two of the most prominent companies. The cables did not, however, work satisfactorily. lasting, as they did, from three months to one and a half years. He lays the cause of failure to the effect of water upon the cable, and the deterioration in the insulation of the wire. His opinion, based upon the tests he has made, is that he does not consider it practicable to place his conductors underground. Considers that the difficulties are both electrical, mechanical and commercial. Had exclusive control over such conduits as he used.

In summarising the results of the experiments in these cities, in one case only did the electric light company place its wires underground willingly. In all others they were forced to do so by the local authorities.

In only one instance have the experiments or practical workings proved satisfactory. The only other case that they did not report adversely, being where the wires had only been in operation about 40 days. The average voltage that they have used on all the circuits tested was 1,893 volts; the current was 10 ampères. The average thickness of insulation over wires was $\frac{9}{32}$ of an inch; and the average length of cables tested in each case, was about 4,600 feet.

In considering the second class of answers—namely, those who have not yet made any extended practical test—their answers have been directed mainly to the last four questions, the first two of which relate to action by the municipal authorities, and the last two consider the practicability and the difficulties of placing wires underground. In very few of these cities have the municipal authorities yet taken any steps towards action upon the matter, having been delayed in awaiting the solution of the underground question in other cities.

In answer to the question, asking them if they considered it practical to place their conductors underground, 104 have replied that their opinions based upon tests that they have seen and such information as they have been able to obtain, both in this country and abroad, is "that it has not been practical to place the wires conveying high tension electric arc light currents underground."

Two have answered that they considered it practical to do so, but state that at the present time they have no wires underground.

In answer to the question which asks their opinion regarding the greatest difficulties to be met with in considering the placing and operating of underground wires, they all unite in the opinion that "the difficulties are both mechanical, electrical, and commercial." They consider that the question of obtaining a satisfactory conduit has not been properly solved; and that even if that should be solved in the future, that we cannot even at this time obtain a satisfactory insulation for the wires that will not deteriorate within a few years, and become perfectly useless as an insulator when subjected to the action of steam, water, and gas. The great difficulty of making connections for buildings and lamps, and the absence of any satisfactory system of subsidiary conduits, is considered by all as a bar to successful operation, as the difficulty of drawing in cables without abrasion to the insulating covering, even with the most careful handling, is very great.

The commercial objection is considered a very great one, as not only is the first cost about eight times heavier than that of an overhead system, but the repairs to the cables due to the deterioration of the insulation, and other defects caused by mechanical or electrical deficiences, would be very much heavier than the expense of operating and maintaining overhead systems, and that the prices at which they are now furnishing the electric light would have to be very materially increased to meet these extra and very heavy expenses. A system of tunnels through all the principal streets is considered to afford the only means for the solution of this problem.

There are many other responses to the circulars, in which the writers state that they have had no experience with underground lines, and have not yet considered the question in the light that we have placed it before them.

The committee also sent a letter asking many of the questions that were sent in the circular, to all of the electric underground wire companies, and in response received quite a number of communications from the cable companies. Most of them said that at the present time they were unable to give any information in regard to underground wiring, as they have had very little experience with wires for that purpose, but that they do not doubt that in the future the state of the art will permit of the wires being placed underground, and that their particular company will be well equipped for doing so.

Other companies reply that the wiring of their system that has been used for underground purposes has been for potentials under 1,000 volts, and that they have met with entire success with potentials of a system with 1,000 volts. And they do not anticipate in the future that they will have any trouble in furnishing wire to meet the requirements of the electric lighting companies, but at the present time they have not yet done so. They unite in stating that they think that the question of the insulation of high voltage of currents should be solved by the using of good durable thick insulation. Their experience in conduits has been, that they do not want creosoted wood, but would prefer to have their wires buried in the ground or under water, and would recommend at the present time that single conductors should be used. They seem to be about evenly divided on the question as to whether lead-covered cables should be used for underground purposes.

On the motion of Mr. Charles Cooper, the report was accepted and placed on file.

COMPOUND-WINDING PATENTS.

KING, BROWN & CO. *v.* ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION.

(Concluded from page 286.)

State wherein the utility of the subject matter of claim 4 consists.—The utility is two-fold. First, in cutting out of circuit armature bobbins at a time when they are unable to contribute current to the general circuit, and thus prevent the discharge and waste of current from the active bobbins through them at such time. Second, in being made metallic and similar to conducting segments, whereby uneven wearing of the general commutator surface is avoided.

Is the fifth claim simply the fourth claim with the further condition that the insulating agent, T, is to form part of an adjoining conducting segment, S, for the purpose of securing greater convenience in attachment? If you answer "No," give the reasons for your answer.—The fifth claim differs from the fourth claim in specifying that the segment, T, is attached to and forms part of adjoining segment, S. The reason for this construction is twofold. It at all times preserves the full width of the commutator in electrical contact with the collecting brushes, and aids mechanical construction and stability.

State wherein the novelty of what is claimed in the fifth claim consists?—In the special and particular construction and combination of the insulating segment, T, with a neighbouring conducting segment, as described in the specification and pointed out in the claim referred to, and as indicated in my last answer.

Explain what is the difference between the subject matter of claim 4 and 5, and how that difference is novel or useful, or the fit subject for a patent?—In my opinion the fourth claim covers the insulating metallic segment in a commutator broadly. The fifth claim covers a special construction not included or defined in the fourth, namely, the metallic insulating segments attached to and operating a part of the adjoining conducting segment, S, substantially as shown in division 3 of the patent. The novelty of the arrangement indicated in claim 5 resides in the peculiar construction pointed out, and its utility is apparent in the direction of facility of making ease and quickness of application, greater security of the insulating segments in its position, and the presentation at all times of the full width of the commutator in electrical connection with the collecting brushes. In these features of novelty and utility, patentability, as I understand, necessarily resides.

Is the sixth claim a claim for the subject matter of the fourth claim carried out in a particular way? If you answer "No," give the reasons for and explain your answer.—No. The fourth is for "the commutator having insulating segments, T." So far as concerns the scope and intent of this claim, as I understand it, the number of insulating segments is not limited. This claim simply requires "metallic insulating segments," having the general functions and advantages of the metallic insulating segments *per se*, as pointed out in the third division of the patent. Claim 6 is materially different from claim 4, not only as covering another and distinct combination of parts, but also in limiting the number of insulating segments, T, that are required on the commutator, as particularly described and explained in the patent as finally amended, page 10, lines 10 to 16 inclusive.

State wherein the novelty of what is claimed in the sixth claim consists?—It consists in such an arrangement or combination that one half of the number of insulating segments formerly required on my commutator are dispensed with.

State wherein the utility of what is claimed in the sixth claim consists.—In diminishing one-half of the number of insulating segments required for the commutator, and diminishing its cost and trouble of construction and repairs without affecting its usefulness or effectiveness.

Is the subject matter of the sixth claim indicated in the provisional specification? If you answer "Yes," point out where, and explain and give reasons for your answer.—I think it is, on the ground that the sixth claim is a specific form of the commutator indicated in the general terms in the provisional specification.

What is the difference between the subject matter of claims 5 and 6, and explain how that difference is novel or useful, or the fit subject for a patent?—The fifth claim does not limit as to the number of insulating segments that may be employed. Either the old full number may be used, or half of them may be dispensed with, as already explained, and yet come within the scope and intent of the fifth claim. The sixth claim covers a construction or combination that diminishes the number of insulating segments one-half, as explained, and this is a distinctive and restricting feature of the sixth claim as compared with the fifth. I have explained the feature of novelty between these two arrangements, and pointed out wherein utility resided. Novelty and utility, therefore, having been shown, patentability, in my opinion, is equally established.

With regard to the compound winding, state what are the differences between the system disclosed in Haddan's patent and that disclosed in Varley's patent, on page 4, lines 11 to 21, and page 8, lines 38 to 49? State whether, in your opinion, these differences, if any, are material; and if you say they are, explain and give the reasons for your answer.—I have already repeatedly stated that I cannot understand that Varley disclosed, or described, or suggested compound winding in the part of his patent to which the question refers, or in any other part of his patent, as viewed in the light of the state of the art at the date of his specification. I still maintain this opinion, and therefore cannot discuss the differences between Varley's construction and the compound winding disclosed in the Haddan patent, as this presupposes or assumes that Varley shows compound winding, which he does not.

State what are the important features and objects of the compound winding as disclosed in Haddan's specification?—The important distinctive and essential features of the compound winding as disclosed in Haddan's patent are, that the field is excited by both the main and the shunt currents; that the main and shunt currents supplement each other, and are not differential or antagonistically applied to the field, and that they serve to mutually correct the evils attending the use of either when employed alone. The objects of the compound winding of the Haddan patent are the maintenance of a constant field or polarity while running the dynamo, and also, so far as may be desired, the maintenance of a constant potential in the dynamo.

Is compound winding better or worse than shunt winding (1) for electro.plating; (2) for electro-lighting? Explain, and give the reasons for your answer.—Compound winding is better than simple shunt winding both for electro-plating and for incandescence electric lighting, because in both electro-plating and incandescence lighting the essential requirements are the same as regards the dynamo. In both, the dynamo must be capable of doing widely varying amounts of work in its external circuit and still maintain a substantially constant electromotive force or potential. This is not practicable with a simple shunt wound dynamo, whereas it is entirely so with a compound wound dynamo.

With regard to the seventh claim, are the two elements of it a shunt coil and a series coil?—The wire or helix, F, named in the seventh claim is a series coil, such as is commonly employed for energising the field of a self-exciting dynamo, and the wire or helix, E, is a shunt coil.

Was a shunt coil, such as is referred to in the seventh claim, known before the date of Haddan's patent?—Not to my knowledge. Such a coil as is "referred to in the seventh claim" is constructed and intended not to act alone as the only exciter of the field, but to act jointly with another coil or helix for that purpose; the other coil or helix being such as is commonly employed for magnetising the field of a self-exciting dynamo. But neither of these coils is made of as great dimensions, electrically speaking, as they would be if used alone. Therefore I do not know, and do not believe that "a shunt coil such as is" referred to in the seventh claim of the Haddan patent was known before the date of that patent.

Was a series coil, such as is referred to in the seventh claim, known before the date of Haddan's patent?—Not strictly speaking. The series coil of the Haddan specification was used in the manner of the series coil of any of the series wound machines, then well known, but not necessarily or commonly to the extent required if used alone. Indeed, it is quite common to construct series shunt machines in which the series coils are alone inadequate to excite the field magnets to any practicable extent.

In 1878, was the purpose of a shunt coil the same as that of a series coil?—No; the same results could not be attained in both cases, therefore the purpose of employing one or the other for both were employed in 1878, or prior thereto, must have been different according to the different results sought.

In the subject matter of the seventh claim is there simply the addition of two methods of producing the same result, both of which were known or in use prior to the date of Haddan's patent? If you answer "No," explain and give the reasons for your answer.—Nothing of the kind. The subject matter of the seventh claim is very different from, and far more than "simply the addition of two methods of producing the same result," whatever is intended to be meant by this quoted part of your question. The subject matter of the seventh claim is a combination of elements and instrumentalities in a dynamo that, so far as I am aware, produced a radically new type among electrical generators. This seventh claim refers to and covers an unitary device, and not "two old methods" in any sense; and this unitary device is a dynamo having distinctively peculiar and highly important and valuable functions and adaptabilities, neither attained nor approximated by any prior invention that has ever come to my knowledge. This machine satisfied wants that were widely felt long prior to the date of the Haddan patent—electro-plating, for instance, and it went into wide and successful use promptly after its invention. It appears to me that this fact alone goes far toward convincing of the fact that whatever older methods might have been known or adopted, their failure to receive the approval and acceptance that was immediately given the dynamo referred to in the seventh claim indicates conclusively that they were not only deficient or inoperative, but that they did not contain or approach the invention covered by said seventh claim.

Wherein does the novelty of the subject matter of the seventh claim consist?—The seventh claim defines and covers a "compound-wound" dynamo, and the novelty enquired of consists in the fact that prior to the Haddan patent no dynamo had ever been known or used that combined or employed, either in substance or effect, the elements named in that claim.

Wherein does the utility of the subject matter of the seventh claim consist?—It consists in all of the benefits and advantages arising from the use of a compound-wound dynamo, and these have been already abundantly referred to. Moreover, they have been recognised by the public for many years.

What is the invention claimed in the seventh claim?—In a dynamo electric machine the wire helix, E, having a comparatively high resistance, and kept in close circuit, while the machine is running in combination with the magnetic wire or helix, F, as commonly employed, substantially as shown in division 4 of the Haddan patent. Such a dynamo is popularly called a "compound-wound dynamo," or a "compound dynamo," or a compound-wound shunt dynamo, or a series-shunt dynamo.

Is the object desired to be obtained by the use of the subject matter of the seventh claim to secure a constant potential, with a varying amount of work done by the machine? If you answer "No," explain and justify your answer.—That is one of the objects. The compound-wound dynamo, however, which is the invention of the seventh claim, broadly considered, may be constructed to more or less nearly approximate or depart from constant potential as particular need may require, without at all departing from the scope and intent of the seventh claim, as I understand it. It is my own practice in the construction of compound-wound dynamos for incandescence lighting to attain, not constant potential at the terminals of the machine, but constant potential at the lamps themselves. For this purpose I so arrange the compound-winding that the potential at the terminals of the machine shall slightly increase with increasing external load, and for obvious reasons. I have adopted this arrangement in most of my incandescence machines. Compound-wound dynamos may be constructed to produce varying electromotive force within considerable limits as well as varying current. This is a mere matter of proportioning the parts of the machine according to the result desired.

State what is disclosed in Haddan's specification as to compound winding, which was not previously disclosed in Varley's specification.—Everything. The Haddan patent definitely and completely discloses compound winding, whereas there is nothing in the Varley patent that disclosed it, but on the contrary, all of the interpretations that can be gathered, however dimly, from its vague, incomplete and uncertain statements, and its drawings, taken as a whole, are entirely repugnant to the conclusion that Varley had ever conceived of the idea of a compound wound dynamo, and much less that he disclosed such an invention in his patent. If Varley in his patent had intended to disclose any idea of a compound wound dynamo, or to indicate any form or construction of such an invention, it is impossible for me to explain or to understand why he did not make such a fact at least remotely apparent in the specification and drawings or the claims of his patent. The drawings do not illustrate or suggest compound winding. The specification did not disclose it, and the claims do not in the remotest degree refer to such an invention or to anything that would require a compound wound dynamo or suggest its desirability.

What was the improvement, in your opinion, secured by Haddan's patent in 1878 and particularly by the seventh claim thereof, being that for compound winding?—If I understand the question, I have more than once answered it.

Was the only object of the seventh claim, as at 1878, to improve the application of electricity to electro-plating? If you answer "No," explain your answer and state what the other object or objects were?—I recognised the fact in 1878 that a compound-wound or permanent field dynamo might have other useful applications than that of electro-plating, and I indicated as much in the Haddan specification, which reads "other useful applications of a more permanent field machine will readily suggest themselves." In the specification of the Haddan patent I referred particularly to the suitability of the invention for electro-plating, because at the date of that patent the process of electro-plating was the principal application for dynamo machines of the type described in the Haddan specification. But besides electro-plating, I had also in mind telegraphy, as several dynamos had at that time been constructed or attempted by others for the purpose of telegraphy. When I invented the compound-wound dynamo I considered that the invention was entirely mine, not only for such purposes as I then knew it might be suitable for, but equally for all other uses that might in the future be developed by the growth and extension of the electric art, which was at that time making rapid and important strides in every direction, and, therefore, perhaps I might have better expressed myself in the Haddan patent and meant the same thing by saying "other useful applications of a permanent field will readily suggest themselves wherever in the present or future development of the electrical art the results sought to be obtained will be effected or assisted by the employment of such a machine as I have invented and here disclosed." In 1878 it was clearly apparent that electricity and electrical apparatus were to have almost unlimited popular adoption, and no one pretended to foretell or to define its limits, and the language of the Haddan patent was written when it was intended to apply to the future as well as to the present time the statement that "other useful applications of a permanent field will readily suggest themselves."

What is the ordinary signification of the expression "permanent field" amongst electricians?—I should say that the expression "permanent field," abstractly considered, would signify a field of constant polarity, and one not liable to reversal under normal conditions.

In compound-winding is the whole of the electricity produced by the machine used by the magnets?—In a compound-wound machine the field is excited by two currents acting in the same direction, one being that traversing the shunt and the other that traversing the main or series coils. The entire electricity or electric current of the machine divides itself between these two circuit, and is used in them to excite the magnets.

Would there be any difficulty from Varley's description in connecting the wire of greater resistance? If you answer "Yes," explain and give the reasons for your answer.—There would. Varley does not instruct on this point, and the drawings do not show "the wire of greater resistance" at all.

If on page 8, line 38, of Varley's specification "electricity" is held as equivalent to "electric energy," does the passage correctly describe compound-winding? If you answer this in the negative, explain and give the reasons for your answer.—Not correctly. The passage would then read in substance, "Part of the electric energy developed by the machine is diverted to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce the electric light." This would not correctly describe compound-winding, because in compound-winding not only is a part of the electric energy diverted to energise the field magnets, but also a part of the remaining portion of the electric energy is used or absorbed for the same purpose, and to this extent, which is considerable, cannot be held to produce the electric light. I will add that I cannot accept as justified by Varley's specification the definition of the word electricity of page, 8 line 38, as being electric energy as the question provides.

Is the mode of connecting the wire of greater resistance not correctly described on page 8 of Varley's specification?—I do not know what mode of connecting is intended in the question and I fail to find any mode described in Varley's patent. Varley simply tells us that his wire of greater resistance is wrapped around the soft iron magnets and has various functions, but leaves us to infer, if we can, how it is connected with other parts of the machine.

Refer to Varley's specification, page 8, line 46, "The method I prefer is to wrap the soft iron magnets with two insulated wires, one having a larger resistance than the other;" that is true of compound winding, is it not?—Yes, abstractly and separately considered in the light of our present and advanced knowledge of compound wound dynamos, and aside from other portions of Varley's patent that bear upon and confuse the meaning, whatever it may have been, of the passage quoted in the question. The language of the quotation is equally applicable to methods of energising field magnets other than compound winding; such, for instance, as the double series winding of Varley's 1867 patent, alluded to in Varley's patent under discussion.

"The circuit of larger resistance is always closed." Is that also true of compound winding?—Yes, abstractly and separately considered. It is equally true of simple shunt winding.

"When the electric light circuit is opened from any cause, the electricity developed passes through the circuit of greater resistance only and maintains the magnetism of the magnets." Is that also compatible with compound winding?—Yes; and equally so with the simple shunt winding.

Referring to page 8, line 50, down to the end of line 40 on page 9 of Varley's specification, is there anything in this part of the specification that is inconsistent with compound winding?—That part of the specification referred to appears to relate entirely to the construction and operation of an electric arc lamp, and to have nothing whatever to do with any particular construction of dynamo machines used to operate the lamp, except by natural inference that a constant potential dynamo was not intended to be used, as it is well known that a constant potential dynamo is the worst possible one for operating an arc electric lamp.

"The insulated wire composing the helices is connected to the insulating wire surrounding the soft iron magnets of the machine, and is usually inserted in the circuit of greater resistance," page 9, line 21. Is this inconsistent with compound winding?—No. Abstractly and separately considered in the light of our present knowledge of compound winding, and laid aside from other portions of Varley's patent that bear upon and confuse Varley's meaning, whatever it may have been in those passages where he makes reference to two wires wrapped around his field magnets.

Is the description in Varley's specification, beginning at line 40 on page 8, and ending with line 23 on page 9, inconsistent with a single commutator double shunt machine, that is to say, a shunt machine which has two wires on the field magnets, one being of low resistance and one of high resistance, and both used as constantly closed shunts to the working circuit?—In my opinion the language of the specification referred to is, by itself, inconsistent with the construction set forth in the question, but the contents of the specification immediately preceding the portion referred to is quite consistent with such a construction.

Would a Varley machine wound with series and shunt magnet coils acting together be an infringement of Haddan's specification if made now?—I would be glad to answer this question definitely if I could determine to my satisfaction what sort of a machine a Varley dynamo is or was. If Varley should wind, connect, and use his machine in the manner customary with "compound wound" machines as such machines are at present made and used I would say that such construction would infringe the Haddan patent. But Varley does not appear to have done or indicated this.

Is Varley's method of winding his magnets an improvement upon any form of dynamo in existence at the date of his patent?—Two things at least are wanted to answer this question. First, such a machine as Varley actually intended to describe, whatever that may be; second, an accurate knowledge of every dynamo that was in existence prior to the date of Varley's patent. I would hesitate to give an answer to the question without this data at hand, and I do not see that a reliable or intelligible answer could be given without comparative tests between Varley's dynamo and its predecessors. I will not therefore attempt to answer the question.

If you say there are any differences between the apparatus described in Clark's patent, No. 4,311, and that claimed in Haddan's, explain fully what these differences are?—The subject matter of Haddan's claims 1, 2, 3, 4, 5 and 6 are not described or hinted at in the Clark patent. The 7th claim of the Haddan patent is for a "compound-wound" dynamo, or, more strictly speaking, refers to features of such a dynamo. Clark's patent does not show or suggest a "compound-wound machine," but only one of "simple shunt" type. These differences are radical.

If you say there are any differences between the apparatus described in Clark's patent, No. 4,311, and that described in Haddan's, explain fully what these differences are?—The differences are those that exist between two radically different machines, namely, a "simple shunt" dynamo, such as Clark's, and a "compound wound" dynamo, such as Haddan's.

If you say there are any differences between the apparatus described in Sir Charles Wheatstone's communication and that claimed in Haddan's specification, explain fully what these differences are.—Sir Charles Wheatstone's paper makes no reference whatever to any of the subject matter of the first six claims of the Haddan patent. The differences between what is suggested in the Wheatstone paper and the subject of Haddan's seventh claim are those differences that are found between a simple shunt machine, as suggested by Wheatstone, and the compound wound machine, as referred to in Haddan's seventh claim.

In conclusion, the witness explained that he had no personal knowledge of the Siebe-Gorman machine, or of the machine made and used by the Electric Engineering Company, of Mill Street, Ancoats, nor did he know of any commutator called the Wilde commutator.

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

(*Concluded from page* 282.)

[ERRATUM.—On page 281, line 27, of last week's issue, for "converters" read "feeders."]

ROME.

The station at Rome, started by the gas company in that city, is the finest example of an alternating current contral station which I have yet seen. But it has been very costly to establish. Many of the details contain hints of the greatest use to those who are at work on this subject. The whole plant has been contracted for by Messrs. Ganz, of Buda-Pesth.

There are two self-exciting alternators of 150 horse-power each, and two independently excited ones of 600 horse-power each. These give 42 ampères and 160 ampères respectively, and 2,000 volts. At present 9,000 glow lamps of 16 candle-power are supplied, and over 200 arc lamps. All the machines are capable of working in parallel, even the large and small ones together. The number of alternations is 5,000 per minute, or 2,500 complete periods. The greatest distance to which current is at present supplied is 4½ kilometres, or about 3 miles. The feeders all go to the Piazza Venezia, and then branch off into three mains in different directions. The loss in the secondary circuits due to loss in the feeders at present is only 0·6 volt at the maximum, and that due to the mains is the same, the length of feeders being 1,600 metres.

Siemens's concentric conductors are used throughout. The feeders are each 220 square millimetres section, or 0·35 inch. The cables are laid in a wooden box, which is then filled with cement. Seventeen kilometres of cable have been laid up to January, 1889. The feeders have been working since September, 1887. The transformers are all of 10 horse-power, with about 4 ampères in the primary and 75 in the secondary. 110 volts are used in the secondary, but the secondary coil has three terminals, one halfway along the length of wire. This is to enable a three-wire system to be used for the secondaries when arc lamps are used, consuming, with their resistances, 55 volts each.

The old type of converter, with iron wire wound round the copper coils, has been abolished. The iron part is built up of circular flat ring-shaped discs of iron. These are firmly clamped together by iron clamps, which form the support of the instrument. The copper coils are wound upon the segments of the rings between the clamps. The primary coil is underneath the secondary. The converter has an iron circular disc at top and bottom fixed to the clamps, and this enables the instrument to be easily rolled about without injury, which facilitates handling. On the top is a porcelain disc, on which are placed the terminals and fusible cut-outs. These are short strips of thin metal held in pasteboard, and can be slipped in and out with the greatest ease.

The small machines are intended to work 1,000 lamps of 60 watts. There are 20 poles, and 250 revolutions per minute. A derivation is taken from a commutator to excite the machine. Sulze engines are used for these dynamos, acting direct on the dynamos. The steam pressure is 120 lbs.

The automatic resistance for regulating the exciting current, invented by M. Blathy, is very effective. The exciting current passes through a solenoid actuating an iron rod which is supported at one end of a balanced lever. The bar is weighted with a float in water, and water can be put into the float. On the top of the iron bar is a cup of mercury which, in falling, breaks contact with the ends of wires dipping down into the mercury cup. These ends are at different depths, so that the wires are cut out of circuit in succession. The wires go to resistances. This automatic adjustment acts well over a considerable range.

The exciters for the large dynamos are driven by Westinghouse engines. They are governed by hand for the large changes, and then the automatic regulation comes in. Such a method of regulation is necessary with machines having so large an amount of self-induction. This is the only satisfactory regulation of the kind which I have seen at work. It is one of the small details on which the success of a station depends, but which are often forgotten by the inexperienced until the want is felt.

The two large machines have 40 poles each on the revolving field magnets. Both field magnets and armature are divided into two series in parallel. When the machine is illuminated by an arc light, to which it supplies the current, a curious optical effect is produced. The arc being periodically made and broken, the revolving magnet poles are seen fixed in position, and the amount of lag with different loads can be seen directly. The efficiency of these machines is said to be 90 per cent., including the exciting current. These machines are so constructed that the cover which contains the armature coils can be drawn away, by means of a handle, shown in the photographs exhibited, over the electromagnet ring, without the necessity of using any hoisting tackle or other machinery. Moreover, the construction of the fixed armature is such that any single coil can be removed in a few minutes, or exchanged. The iron of a section of the armature is in this case removed with the coil. The iron plates of which these armature sections are made are T-shaped, so that the centre of the coil is filled with iron. In the smaller machines there is not nearly so much iron in the coils. In the 600-horse-power machines the energy absorbed in exciting at full load is said to be 3½ per cent. of the full load.

The T-shaped iron plates of the armature are pressed together by strong bronze press plates and a screw. The wire bobbin is then slid on and held by screws. These segments are fastened to two traversers by the screws, which traversers are in turn screwed with an insulating layer to the side plates of the framework of the machine.

The field magnet wheel is constructed as follows :—U-shaped soft iron sheets are so arranged together as to form a star, to which is added a similar star, with an insulating layer between, placed in such a way that the interstices between the sheets composing the lower star are covered by the sheets of the upper star. In this way many iron laminæ are put one upon the other until there are sufficient to form the whole electro-magnet wheel. The pile so formed is then pressed together to form a compact whole by means of two stiff discs, two bosses, and the screws. The bobbins are slipped on to the core and held down by means of the bobbin holder and screws. The subdivision of the iron in the field magnets is necessitated by the teeth of iron in the armature projecting inwards through the coils.

The large engines are by Ganz & Co. They are carefully balanced, and are provided with starting gear.

The switchboard is very ingenious, but very expensive. The board is about 8 feet high and 17 feet long. It is divided into four sections, one for each dynamo, and each section is divided into six, one for each pair of feeders. A pair of 4-foot horizontal bars runs along each dynamo section, connected with the two poles of the dynamo. Two vertical bars descend from these at each of the six parts allotted to the six circuits. Six pair of horizontal bars are connected to the six pair of feeders (only three are as yet in use), these pairs being one over the other. At each feeder section a pair of vertical copper bars descend from the horizontal feeder bars corresponding to that section. Thus we have at each feeder section two vertical dynamo bars and two vertical feeder bars, the lower ends all being at the same level. Mercury cups can be raised to connect each dynamo bar with a feeder bar, or lowered to disconnect them. The chief object of the switchboard is to enable us to switch any number of dynamos in or out of connection with any feeders simultaneously and instantaneously.

The voltmeters in this station by which the pressure at the lamps is kept constant are regulated by means of two circuits, one being a shunt on the dynamo terminals, and the other carrying the main current. These are passed through converters, and the secondary currents actuate a solenoid in opposite directions. This compound-wound voltmeter indicates the pressure at the lamps, and is maintained constant. Prof. Mengarini has devised an ingenious recording voltmeter for marking in a daily curve the pressure at the dynamo terminals at each minute of time. These show variations of 5 volts at different hours.

There are 50 converters now at work, each of 10 horse-power. The efficiency of these converters is 95 per cent. at full load. That of Messrs. Ganz's 5 horse-power converters is 92 per cent., and the 2½ horse-power is 88 per cent. This is far higher than with many of those now made in England. The House of Parliament is lighted by four banks of five converters each.

PART II.—LESSONS TO BE LEARNED FROM FOREIGN CENTRAL STATION LIGHTING.

I propose now to deal with some of the problems of central station lighting which we in London have now to face.

I judge by the practices I see common in this country that I shall, as to my opinions on many points, be at variance with some of my brother engineers, because in the work which has hitherto been done I see that the experience of foreign countries has very often been neglected; and the rule seems to be to neglect the opportunity of utilising the experience gained at great expense of time and money in foreign countries, while our progress was being retarded by the Electric Lighting Act. But my conclusions have been arrived at after a most careful consideration of the successful work which has been done in Europe and America, and I am ready to condemn foreign practice when necessary. All I say is, that we ought to benefit by the experience abroad, and I know that those who have the best interests of electric lighting in England at heart agree with me.

This neglect of the principles laid down in other countries I find to exist whether the central station be used for continuous or alternating currents. I forsee great danger in store for us if we do not discuss the difficulties fully at the outset, and I trust that the discussion that this part of my paper will give rise to will assist to make the progress now being made in England a thorough success.

THREE-WIRE SYSTEM.

My first remarks will be about the direct system of supply at low pressure—a system which may be much more frequently employed with advantage than many people seem to imagine. It is not suited for a large district, but it has some advantages.

1. That the steadiness of the light can be increased, the fear of accidents diminished, and the amount of machinery reduced, by the employment of storage batteries.

2. If batteries are not used, the loss of energy in transformation is avoided.

Let us deal first with the case where all the dynamos are working in parallel at the same pressure. This is the Edison plan, and is very generally adopted. I have shown in my Cantor Lectures* that when we extend beyond a certain distance from the central station on the system at present used, the question of economy, as established by Sir William Thomson's law for the size of conductors, must be partially abandoned, and a different size used, in order to prevent the variation of electrical pressure over the area being too considerable under the varying loads. With the "two-wire" system the law of economy holds only up to a very short distance; with the "three-wire" the distance is doubled. This is due to the fact that the pressure is doubled, and this is the principal advantage possessed by the three-wire system. In Berlin and Milan the two-wire sytem has hitherto been adopted, and the enormous amount of capital expended in copper is a proof of the costliness of the system. I hold that in no case of central station work at low pressure ought the two-wire system to be adopted. In this I am supported by the universal practice in America, where the two-wire system for low pressure distribution is now totally abandoned. I am also supported in this by the practice in Berlin, where all future work is to be done on the three-wire system. In spite of these considerations, I am not aware of a single case where it is in actual use in England since the experiments at Leamington have been abandoned. The two-wire system is used at a good many places in this country. The result of experience probably is that the three-wire system can be profitably worked to a maximum limit of half a mile where the price of gas is over 5s. per 1,000 cubic feet; beyond that distance the profits diminish too much. In London I do not think it could be well done beyond 400 yards as a general rule.

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* Cantor Lectures, "On the distribution of electricity," *Society of Arts Journal*, 1885.

FEEDERS.

I now come to another principle of distribution which is strangely, and I believe almost universally, neglected in this country. I refer to the use of "feeders." Let me distinguish between the use of feeders and mains. Mains are conductors from all parts of which branches may be laid into the houses. Feeders are conductors leading from the central station to various points in the system of mains, and which are not tapped on the road. In Berlin and Milan the practice, first started in America, is followed of laying down a network of mains and supplying current at numerous points in them by means of feeders. This serves to equalise the pressure over the entire districts under varying loads. In England this practice is not generally adopted. The result is that if you wander over a district supplied by electric light in England, you find that when the supply of current is small the lamps are equally bright over the whole town, but when there is a large demand for light the glow lamps near the station are far too bright and those at a distance are far too dull. In Berlin, where half the capital spent in conductors has been used for feeders, the lamps are, all over the district, equally bright at all times. Not the slightest difference can be perceived at different hours of the day or night. I hold the opinion that a station with low-tension current without feeders is badly engineered.

USING DYNAMOS AT DIFFERENT PRESSURES.

It is the universal practice abroad to make the size of the feeders such that the loss of pressure in these feeders is the same in all. This involves the use of very large feeders when their length is great, and great waste of energy when the length of feeder is small, but it enables all the feeders to be supplied by dynamos at the same pressure, which may therefore work in parallel. This arrangement is simple to work, but it is wasteful. I find that we can save enormously in copper at a slight extra trouble in working the central station. I would prefer to see the feeders divided into two or three groups, feeders in each group having the same length, and having the same loss of pressure. All these feeders would be made of the economical section, according to Sir William Thomson's law. When the station is at full load the dynamos working long feeders have a higher pressure than those working short feeders. When the load is light all the dynamos would work at the same pressure, because the loss in the feeders is insignificant. At such times all the dynamos might be, joined in parallel, or the feeders might all be upon one dynamo.

POSITION OF PILOT WIRES.

In nearly all cases of low-pressure distribution the pressure is regulated by a "pilot wire" coming from the point where the feeder meets the main. These pilot wires indicate the pressure at those points upon a voltmeter, at the station, which is kept at constant reading by an attendant. Sometimes all the different pilot wires are grouped together at the station and indicate the average pressure on the voltmeter. This is done at Berlin. At Milan, however, the pressure is varied according to a tabular rule when the current varies. The use of pilot wires is, however, very desirable, but I hold that hitherto the pilot wires have generally been placed in the wrong position. Suppose that a 4 per cent. variation exists over the district of mains supplied by any one feeder, and that the point where the feeder strikes the mains is kept at constant pressure, then the most distant lamp supplied by that feeder has a variation of 4 per cent. If, however, the pilot wire came from a point half-way between the most distant lamp and the feeder, and this point were kept at constant pressure, the maximum variation of pressure would be reduced to one-half, and would be only 2 per cent. It appears, then, that by properly placing the pilot wires the variations in pressure can be reduced to one-half; or, keeping the variations of pressure the same, the quantity of copper in the mains may be reduced to one-half.

In these suggestions as to dynamos at different pressures and as to the position of pilot wires I am supporting a course which has not been generally adopted anywhere, but the improvement ought only to be mentioned to receive general recognition.

LAMPS OF DIFFERENT VOLTAGE.

It has often been proposed to supply different parts of a district with lamps of different voltage. In the ordinary plan of using feeders and pilot wires the maximum pressure at the most distant lamp supplied by any feeder is the same as the pressure in the mains at the feeder. The minimum pressure may be, let us say, 4 volts less. Suppose 100-volt lamps are used, those near the feeder will always have 100 volts, but the most distant ones will have pressures varying from 96 to 100 volts. Ninety-six volts would make the lamps very dull; and if at the distant points lamps of 98 volts were used, the pressure would never vary more than 2 per cent. from the normal, and a better light would be obtained. This would be a very good arrangement if we could lay out a district from the beginning with all the positions of the lamps established, but it is found that as the station progresses a house which would have required 100 volts yesterday may require a limit of only 99 volts to-day, owing to the introduction of additional lamps between it and the feeder. Experiments which have been made in America on this plan have led to disastrous results and hopeless confusion in completing the scheme. This plan has been completely abandoned, and in the present state of the industry I think that this abandonment has been wise.

I do not think a greater variation of pressure than 2 per cent. up and down should ever be allowed if you wish to supply a satisfactory light.

I consider that success or failure of many electric light companies now doing central station work is very much dependent on their following or neglecting the proper rules for distribution, and I will illustrate the importance of these rules by a few examples:—

1. A plain network by the two-wire system, fed at the central station with the economical size of copper conductors according to Sir William Thomson's laws—say, of 1,000 ampères per square inch—and going to a distance of 480 yards, would have a difference of pressure to which the distant lamps would be subjected of 24 volts.

2. On the three-wire system this would be 12 volts with one-fourth extra copper.

3. With the same amount of copper as in the last, properly arranged with feeders, the feeding points being 160 yards apart, the maximum variation of pressure in any lamp over the district is 2 volts, if the pilot wires come from the feeding centres.

4. Everything remaining the same as this last, except that the pilot wires are placed in the proper position instead of at the feeding points, the maximum variation is only 1 volt.

Putting it in other words, the quantity of copper required to limit the variation of pressure over the district to a certain figure is in the last case one-twelfth part of what it is in the second case, and one nineteenth part of what it is in the first case.

HIGH-PRESSURE DISTRIBUTION.

Before I leave the question of distribution let me now apply the same rules to the "Gaulard and Gibbs" system of using alternating currents with high pressure in the mains and low pressure in the houses, the reduction in pressure being effected by means of an induction apparatus called a "converter." At the present moment these converters are usually put in parallel upon the mains. There is a general impression in this country that it is not necessary to have feeders supplying the mains, even though the distance extends to several miles. Here, again, the experience of other countries has been set at defiance, although in a large town like London the importance of this rule is greater than in most American cities, or in Rome. If such views continue to be adopted, the result will be as disastrous in the future as it has been in the past. In the most extensive system in this country, when there is a large demand for current, the distant lamps look like red-hot hairpins, even though the near lamps be at full brightness. This is due to defective distribution.

As already stated, there is a general belief in this country that to whatever extent the Gaulard and Gibbs system is used no trouble comes from variations of electric pressure over the district, even when the converters are placed in parallel. Let us look at this question a little closer. Returning to the two-wire system for low pressure, if we use 1,000 ampères to the square inch as the economical section for our conductors, the fall in pressure is 5 volts for 100 yards; the loss of pressure due to the house wiring amounts very generally to 2 volts—hence the total variation between the periods of maximum and minimum output is 7 volts per 100 yards, or about double what is permissible (4 volts); hence with the two-wire system such a size of conductor at 100 volts pressure could only be used for a distance of from 40 to 50 yards. Let us see how this distance is extended by using a pressure of 2,000 volts in the mains and 100 volts in the secondary. With the same density of current the loss of pressure in the house will be now 5 volts for 2,000 yards, to which must be added 2 volts for the house wiring and about 1⅓ volts for loss in the converter, making 8⅓ volts loss of pressure in 2,000 yards.

If we allow 4 volts variation in the lamps, which is quite a maximum, this allows only ⅓ per cent. variation in the mains, and then the greatest distance to which conductors can extend is 200 yards. The only means of extending the district is by the use of feeders. In America the practice prevails of allowing only ⅓ per cent. loss of pressure in the mains. I have taken a concrete case of 1,000 ampères per square inch, which may not always apply to actual conditions, but it shows the necessity of adopting the universal foreign practice of employing feeders even with high-pressure mains.

PRESSURE INDICATORS ON HIGH-TENSION CIRCUITS.

It would be highly inconvenient to use pilot wires with the Gaulard & Gibbs system, such as are used on low tension circuits; for this reason compound wound voltmeters are used, which indicate the pressure at the far end of the feeder. I have described those in use at Rome and Milan; I have also described elsewhere those used by Westinghouse in America. The principle of these indicators is to have one winding connected like an ordinary voltmeter with the terminals of the dynamo, and another winding in reverse direction to carry the main current. The diminution in the indication owing to this second winding is always equal to the fall of pressure in the feeders. Different inventors have applied different classes of apparatus for accomplishing this result, but it is needless to say that the working out of such instruments takes a long time, more especially in such an instrument as that employed by the Westinghouse Company, which is made interchangeable for all circuits by the insertion of six different plugs, representing six different losses in the feeders, converters, and house wiring, varying from 3 per cent. to 10 per cent., besides four plugs for the different maximum currents in use with any feeder. I draw attention to this point because I consider that the successful working of such a central station depends largely upon the use of such an indicator of pressure; and I find manufacturers in this country who have had little or no experience in central station work, prepared to equip central stations with all the necessary measuring instruments, and I wish to feel confidence that these manufacturers have realised the importance of such instruments; and I wish earnestly to impress upon them, solely in their own interests, the necessity of working out such instruments if they wish to redeem electric lighting in the metropolis from the condition into which some of the so-called pioneers of this industry have reduced it.

Insulation.

We have now to consider a very important, and perhaps the most difficult, part of the problem of central station lighting—How are we to preserve our insulation? It must be noticed that we do not require a high insulation for the sake of getting a small loss of current, but only because with many insulators the high insulation is more permanent, and permanency is the quality of insulation which is most to be desired. I am not going to discuss at present the whole question of insulation, but rather to draw conclusions from the experience of the past. At the present moment vulcanised India-rubber and okonite are the substances which have the highest reputation for durability and high insulation under all conditions. These, like other cables, are sometimes covered with lead, but in their case it is only as a mechanical protection, especially during the process of laying, because the destruction of the lead would not destroy the insulation. Of late years a class of cables has been much praised about which I wish to speak. The copper conductor, stranded or otherwise, is covered with any fibrous material, preferably jute, impregnated with bituminous oils. This covered core is enclosed in the lead pipe. In this class of cable the insulation depends upon the lead being watertight. We all know of many places where this type of cable has done good work for a limited time, and many of us were inclined to believe that it was quite satisfactory; but I think I am right in saying that none of us know of its having worked successfully in any place for three or four years. I have said that a cable of this kind has hitherto been exclusively used in Berlin, the lead being covered with layers of tape or braid soaked in a preservative compound, and the whole armour-plated with two closed spirals of iron ribbon. I regret to have to tell you that this insulation has been a failure. It goes on well enough for about three years, then the lead gives way, the covering on the copper is permeated, and chemical or voltaic action sets up in the copper, which itself becomes disintegrated. So far as experience goes, this type of cable seems to me to be unsuitable for permanent work with the electric light. I trust that in the discussion we shall have some facts brought out. I had hoped, from what Berthoud and Borel, and also Waring, had done, that this would not be so, but the Berlin experience leads me to think otherwise; and on looking through the testimonials of makers I do not find that these cables, when placed underground, have ever worked electric light circuits beyond the three years fixed by the Berlin people as being destructive. I have been told, but I cannot believe it, that there is one company in London actually proposing to put such lead-covered cables without covering into iron pipes. Of course everyone knows they would soon be eaten into by galvanic action.

At Berlin and elsewhere I believe there is the intention of trying some modification of the system of using bare conductors, first practically used by Mr. Crompton at South Kensington. Taking economy into account, it is probable that for low-tension circuits this is an admirable plan. It is probable that it may also be adapted to high-tension circuits by using oil insulators to support the bare conductors. When copper strip is used it is necessary to raise the cover of the trough in order to increase the number of conductors; this is very expensive. For my own part, I would prefer a drawing-in system, if it were otherwise equally good.

No information has ever been given as to (1) the maximum or (2) the minimum insulation resistance of the conductors at Kensington Court, but perhaps this information will be given during the discussion.

At the present moment it seems to me that the only types of underground cable proved suitable for permanent work are either bare copper supported on insulators, or else vulcanised India-rubber, or perhaps okonite. Especial care must be taken to avoid an insulator which is injured by the gases which permeate the soil of a town, or which has the property, like pitch, of becoming viscous, and so letting the copper become decentralised.

Meters.

The next lesson which the experience of foreign stations in Europe and America has taught us is the importance of charging the consumers of electricity by meter, like gas. I find that at present most companies in this country are charging the larger proportion of their consumers by contract, making an annual charge for each lamp. This appears, from evidence collected everywhere, to be a fatal mistake. It is the universal experience that those stations pay best where meters are used. In many stations it is found to be the best plan to make a fixed annual charge, which may be put down as the rent of meter, and then an additional charge proportionate to the quantity of electric current supplied. This has the advantage of preventing customers putting in place a large number of lamps which during the greater portion of the year are idle, but which on festival occasions may all require current. Such idle lamps are very expensive to the suppliers, because a large reserve of machinery must be lying idle during the whole year to be ready for such occasions.

Within the last month I have described before the Society of Arts * the different meters which are valuable, without pretending to estimate their relative value. For continuous currents we have the Edison and Aron meters, for alternating currents we have the Schallenberger meter, and for both classes my own "Windmill" meter.

Converters.

The induction apparatus used with alternating currents is called a "converter," "secondary generator," or "transformer." The reduction of pressure from the primary to the secondary circuit is generally 20 to 1, but sometimes more. A large number of types have been invented. I have elsewhere described the Westinghouse converter, which I have tested and found to be very efficient, even though the largest one he is in the habit of supplying is only for forty lights.

Only the larger size of Zipernowski converter is so efficient. Three sizes are made, varying in efficiency from 95 down to 88 per cent., though the latter is a converter suitable for twenty-five lamps. Many of the types which are made in England I feel sure are far from efficient. There is a general opinion that the loss in the converter is necessarily small. This is by no means the case. A great deal of care must be taken in the design to get a satisfactory result. I think there is a general idea that any of the converters now on the market in England will give an efficiency for the average number of lamps in circuit of about 90 to 95 per cent. I should be much surprised if there are more than two types in use in this country which have an efficiency for the average number of lamps over 70 per cent. Yet, so far as I am aware, no maker in this country ever tests the efficiency of the converters which he supplies. The efficiency of a converter falls when it is underloaded. If the converter in a house is adapted for 100 lamps, and only three or four lamps are in use. then, with many converters, the current which is being used is double or treble what is required for the lamps. This defect in some converters is clearly shown in the load diagram of the Grosvenor Gallery installation, where during the hours of minimum supply the current sent out from the station is seen to be abnormally high—far above that of the load diagram of other central stations—and at the hours from 4 to 6 a.m. in October current sufficient for 4,000 lamps is indicated on the station meter. This curve shows a loss of 20 per cent. The type of converter which Westinghouse has perfected is one of low magnetic resistance. The worst ones now being made in England are of high magnetic resistance. The waste in a converter, independent of magnetic friction, varies as the square of the magnetic resistance.* The waste due to magnetic friction varies as the length of the magnetic circuit, if the induction in the iron is the same. These high magnetic resistance converters require a great deal of copper. The magnetic friction is so great that they would probably work better with an open magnetic circuit, as shown by Lord Rayleigh (*Phil. Mag.*, 1886).

Slow and High-Speed Engines.

I need hardly tell you that the most startling difference I found between the best European and American practice is the question of speed of revolution of dynamos. In America 1,000 revolutions a minute is the normal speed for an alternator of 250-horse-power; in Rome the 600-horse-power dynamos revolve at 125 revolutions per minute; at Berlin the 400-horse-power engines at 80 revolutions per minute. In Europe there is a tendency to condemn high speed as such, whereas high speed is more objectionable only in the type of machine where the revolving part is more massive, less perfectly balanced, less capable of standing centrifugal strains, and has a longer distance between the bearings. In every other point high speed is an advantage, especially in economy of plant. Now compare the Zipernowski and the Westinghouse dynamos, choosing of the former the one without Pacinotti teeth on the armature, as made by Elwell-Parker. These two machines are electrically identical, but in one the armature is fixed, in the other the field magnets. The armature can, and the field magnets cannot, be perfectly balanced. The weights are not very different. The armature is more capable of standing centrifugal strains than the coils of the field magnets. For all these reasons the Westinghouse may be run at high speed and gain all the advantages of economy. Of course the necessity of introducing belting has to be considered in this case. But then turn to the Parsons alternator, which drives direct, and being the lightest, best-balanced machine, with great capacity of resisting centrifugal strains, and with the only scientific bearings in the market. Here we have a machine where all the advantages of high speed may be safely acquired and great economy introduced. People are apt to forget that slow speed means large machines with no increase of output.

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* *Society of Arts Journal*, January 25th, 1889.

* See my formulæ for converters, *Journal of the Society of Telegraph-Engineers and Electricians*, Vol. 17, Part 71, p. 153.

SPEED OF ALTERNATIONS.

Now I come to a very important point. What speed of alternations shall we use? In Rome they have 83 alternations, or 41 complete periods, per second. In America the Westinghouse Company have 267 alternations, or 133 periods, per second. What are the advantages and disadvantages, and why have these makers adopted different plans? I will answer this in detail to the best of my ability. First, Westinghouse went to rapid alternations because he wanted his converters to be of reasonable size. Second, he wanted to economise plant by using high speeds, and it would be very difficult to have slow alternations with high speed. Third, Gans & Co. (Zipernowski) wanted to drive their machines at slow speeds, under which circumstances they cannot easily get rapid alternations. This is how these things were arrived at. Now let us see what the results are.

1. With rapid alternations the size and cost of the converters is diminished. Most people seem to think this is a small matter. A moment's consideration shows that it is not so. It is found that in most houses the size of converter does not exactly fit the number of lamps, so a size larger must be used. Hence for a 7,500-light plant converters for 10,000 lights are required. The price of these, for the sizes used in houses, is (as the average of many makers) £5,000. The cost of engines and dynamos combined (Parsons) for the same would be about £6,000. You will now see that the cost of converters is as important as anything else.

Mr. Kapp has stated, I venture to think erroneously, that the size does not vary with the speed of alternations. This is opposed alike to experience and theory. Westinghouse knows this. I am informed that Mr. Ferranti knows it, and Mr. Zipernowski has told me so in a recent letter.

2. There is, however, an important gain by slowing the alternations. It is then easier to work in parallel. This is due to the fact that the machines have more time to get into step. If I considered parallel working essential to success I should say, "Sacrifice the cost of converters, and use slow speed." Otherwise I should say, certainly and without hesitation, "Use rapid alternations to increase the efficiency and economy."

WORKING IN PARALLEL.

The experience of Rome is encouraging to any one who thinks parallel working essential. For my part I do not. Sub-division of mains is far more practical in most cases, and enables you easily to cut out special districts if a fire or other trouble occurs. It also gets over the trouble of increased resistance in large conductors with alternating currents, dwelt on by our president in his opening address. If I have more than one station in a town, and I want one to assist the other, I would do so by trunk lines between the stations, to which a dynamo can be attached at one end and feeders at the other. Of course, both stations must supply the same type of converters; hence in such a system it would not do to use dynamos of various speeds of alternations at the different stations. I would certainly prefer parallel working as being simpler for the men at the central station, if no complications are introduced to make the machines work in parallel, and if the system were equally economical, but I do not consider it at all essential. I venture to think, however, that the plan now universally proposed for making machines work in parallel will not long be tolerated. This is to introduce into the machine a large amount of injurious self-induction, thus diminishing the plant efficiency and rendering the equalising of pressure with varying loads very difficult. I have confidence in the ingenuity of our inventors, who will soon devise a less objectionable plan.

AUTOMATIC OR HAND REGULATION.

The question now arises whether the regulation of potential should be accomplished by hand or automatically. In all low-pressure systems, such as Berlin, it is done by hand. A workman soon gets to know at what hours special attention must be paid to this, and on the low-tension system with shunt-wound or compound-wound machines the regulation required is slight. Where the saving in attention is not very great it is always unadvisable to trust to automatic dodges. The case of alternating current dynamos with high self-induction is very different, for the electric pressure then varies enormously with the current. In this connection such a machine resembles a series-wound direct current machine with high resistance. The changes are so frequent that some automatic adjustment is necessary. Ferranti, Lowrie, and others have used the sagging of a wire to effect this, and they regulate the pressure at the dynamo, not at the centres of distribution, which is wrong. The apparatus looks too delicate for an engine room. But Ganz & Co. use a very practical type. They also regulate from the centres of distribution. I also prefer the method used by Ganz & Co. of regulating the large changes by hand, and only the small changes automatically. This is necessary, owing to the very large adjustments necessary with alternators of high self-induction.

In conclusion, I feel confident that all those who are working to maintain England's supremacy in this department of industry will agree with me that the practical details necessary for successful central station working must be thoroughly well thought out beforehand, and that much saving of time and money can be effected by gathering hints from those who have spent years of time and tens of thousands of pounds on these details.

I frankly admit that I have learnt more that is of practical value in this line from the inspection of actual work done than by reading books.

But we must remember that the low price of gas in England, the cheapness of coal, and the relative cost of labour, all introduce special factors which will partially differentiate the English practice either from that of the continent of Europe or of America.

I wish now that the last words of this paper may be words of thanks to the gentlemen in other countries—whether in Europe or in America—who have the control of central stations, for the courtesy which they have extended to me in my endeavours to assist, to the feeble extent possible to me, in maintaining the position of this country in the progress of this new and important industry.

Physical Society, March 9th, 1889.

Prof. REINOLD, President, in the Chair.

Prof. R. Threlfall and Prof. A. S. Herschel were elected members of the Society.

Prof. O. J. LODGE read a paper "On the Magneto-optic Rotation by Transient Currents," with reference to the time required for the production of the effect. If a piece of heavy glass or tube of carbon bisulphide be placed between two crossed Nicols and surrounded by a solenoid, light passes through when a Leyden jar is discharged through the wire. That the discharge is oscillatory may be proved by turning the analyser slightly to one side or the other, this having no effect on the result, or the beam may be examined by a revolving mirror, in which case a beaded band is seen when the discharge takes place. When the spark itself is analysed in the same way, a serrated band results. The frequency of the oscillations being given by the formula $n = \frac{1}{2\pi\sqrt{\frac{LS}{\mu K}}}$ it is evident that n will be decreased by increasing the capacity, S, and self-induction, L; and this fact was demonstrated by connecting two condensers, first in series and then in parallel, and placing coils of wire in the circuit. The pitch of the sound emitted by the spark was by these means brought within the musical scale. Contrary to expectation, the insertion of a coil with an iron core produced little or no change in the pitch, the reason given being, that the induced currents in the skin of the iron wire due to such rapid oscillations of current, prevents the interior being magnetised. From the mathematical theory of the brightening of the dark field, it appears that the relative brightness, B, when compared with the light field obtained from the uncrossed Nicols is given by $B = \frac{1}{\tau}\int_0^\tau \sin^2\theta\, dt$ where τ is the time during which an impression can be accumulated on the retina, and θ the angle through which the polarised beam is rotated. When θ is considered small $B = 16\pi^2 k^2 n^2_0 \frac{\frac{1}{2} S V_0^2}{R\tau}$ where k = Verdet's constant, n = number of convolutions on the solenoid, R = resistance of circuit and $\frac{1}{2} S V_0^2$ the initial energy of the static charge. The general solution is given as

$$B = \frac{1}{2m\tau}\int_0^A \frac{1 - J_0(x)}{x}\, dx, \text{ where } m = \frac{R}{2L},\ A = 8\pi k n \mu V_0 \sqrt{\frac{S}{L}}.$$

Taking the approximate solution, the question as to what is the best size of wire wherewith to wind the solenoid is considered, and as the insulation is very important, it is concluded that the secondary of a Ruhmkorff coil is very suitable. The main interest of the experiment is said to lie in the evidence afforded of the practical instantaneity of the development of the rotary property in the substance under examination, for Villari (from experiments made on a glass drum revolving in a magnetic field) inferred that a distinct time between $\frac{1}{300}$th and $\frac{1}{400}$th of a second was necessary, whereas Profs. Bichet and Blondlot, of Nancy, have concluded that the time required is less than $\frac{1}{30000}$th second. The author finds that carbon bisulphide is able to show the effect when the rate of alternation is 70,000 per second, and has no reason to believe that glass is any way inferior. As a possible explanation of Villari's results, he suggests that the strain due to centrifugal force would modify the components of the polarised beam, and produce elliptic polarisation.

Mr. WARD mentioned that experiments similar to Villari's were now being carried out at the Cavendish Laboratory, a disc of glass being rotated about 200 times per second by means of a turbine. The results so far obtained do not confirm Villari's, but owing to difficulties in keeping the speed constant, it is impossible to make exact measurements. It has, however, been found that the strain due to the centrifugal force rotates the plane of polarisation, and elliptically polarises the beam, and that passing an alternate current round a stationary glass bar produces a distinct rotation of polarised light passing through it.

Referring to the oscillatory discharge of a jar, Prof. RUCKER directed attention to Dr. E. Cook's experiments described before the society in June, 1888. New photographs, showing the dust figures produced by sparks, were exhibited, and pointed out that the frequency required to produce air waves of the length there indicated was of the same order as the rate of oscillatory discharge, viz., about one million per second. Prof. Rucker also wished to know whether glass behaved precisely like CS_2.

Dr. LODGE said his experiments were not exact enough to decide the latter question, and mentioned that Mr. Chattock had some time ago produced dust figures in tubes by jar discharges, and shown that the wave length depended on the capacity and self-induction.

Prof. Ayrton suggested the use of a phonograph as a means of recording and reproducing the oscillations, in the same way as himself and Prof. Perry have analysed the current curves of alternating dynamos. The discharge could be passed through a small coil fixed to a diaphragm, and placed near a coil through which a steady current was passing, the attractions and repulsions serrating the surface of the rapidly revolving cylinder. By means of a mirror attached to a delicate magnifying spring, the section of the surface may be determined.

Dr. Thompson remarked that it was satisfactory to learn that Villari's results admit of an interpretation other than by time effect, and thought it advisable to vary the experiment by rotating a bar of glass, but

Mr. Ward said he attempted that experiment four years ago, and abandoned it on account of the enormous speed required.

Dr. Lodge showed "Some experiments allied to those of Hertz," and pointed out that all the effects were due to resonance. The plates of an air condenser were connected by a wire loop, and placed near a Holtz machine in action. On adjusting the distance between the plates to a particular value, sparks were observed to pass between them; but on increasing or decreasing that distance, the sparks ceased. It was also shown that the sparking was interrupted if the connecting loop was replaced by a coil, though the coil was effective when connected to a condenser of smaller size, thus demonstrating that the time constant of the condenser circuit was all important. Another important condition to be observed in such experiments is that the receiving circuit must be closed except at the sparking place, so as to permit the surgings of electricity to take place freely. Other experiments were shown in which two spheres, provided with rods terminating in knobs, were used as a Hertz's oscillator, and sparks could be obtained from straight pieces of wire of suitable length, held at some distance from the spheres. Dr. Lodge remarked that sparks could be obtained from almost any scrap of wire or metal in close proximity to an induction coil and oscillator; but to produce the effects at considerable distances, careful timing of the receiving circuit was necessary. The author also described the results of some experiments on the velocity with which electric waves travel along wire, and concluded (contrary to Hertz) that this was not greatly different from the velocity of light.

Owing to the late hour, the other papers announced to be read were postponed.

NEW PATENTS—1889.

3327. "Signalling by electricity on railways by means of the train in motion." W. Ballard. Dated February 25.

3330. "Improvements in the application of the electric incandescent light to be used by man or beast." J. Hartness. Dated February 25.

3345. "Improvements in electric light emitting and other conductors." J. Clegg. Dated February 25.

3350. "An improved instrument for measuring currents of electricity." Sir C. S. Forbes, Bart. Dated February 25.

3363. "Improvements in the manufacture of incandescent electric lamps." J. W. Edmundson. Dated February 25.

3365. "Improved apparatus for facilitaing the laying of electrical conductors, chiefly designed for military purposes." L. Kamm. Dated February 25.

3373. "An improved acoustic galvanic apparatus." A. D. Munro. Dated February 25. (*Complete.*)

3401. "Improvements in or connected with current regulators for dynamo-electric machines." E. A. Sperry. Dated February 26. (*Complete.*)

3402. "Improvements in apparatus for metering electric energy." W. H. Scott and Laurence, Paris & Scott, Limited. Dated February 26.

3420. "An improved method of automatic regulation in dynamo machines." J. Sayers. Dated February 26.

3424. "Improvements in dynamo-electric machines and motors." J. Swinburne. Dated February 23.

3456. "Electric circuit couplers." S. C. C. Currie. Dated February 26. (*Complete.*)

3461. "Improvements in and relating to electric regulators or balances." F. V. Maguaire. Dated February 26.

3499. "Improvements in electrical telegraphs for use on board ship." A. Mechan. Dated February 27.

3502. "Improvements in or connected with processes of manufacturing iron wherein the iron is subjected to an electric treatment." A. G. Greenway, B. F. Babcock and B. Radcliffe. Dated February 27.

3533. "Improvements in the extraction of copper and zinc from their ores, as also of the precious metals contained therein, by electrolysis and apparatus therefor." C. D. Abel. (Communicated by Messrs. Siemens and Halske, Germany.) Dated February 27.

3540. "Improvements in electric danger alarms for railway block signals." J. H. Hunter. Dated February 27. (*Complete*)

3556. "An improved method of regulating the current developed by dynamos or magneto-electric machines, and the power of electric motors." O. Firth and E. W. Crabtree. Dated February 28.

3558. "Method of obtaining aluminium continuously in an electrical furnace." H. Kenyon. Dated February 28.

3580. "An improved electric bell or gong." F. H. Berry. Dated February 28.

3629. "Improvements in electric meters." R. Snowdon. Dated March 1.

3662. "Improvements in electric railway signals." T. A. Putnam. Dated March 1.

3671. "Improvements in or relating to winding and synchronising clocks by electricity." A. J. Boult. (Communicated by R. J. Pouchard, France.) Dated March 1.

3674. "Improved method of and apparatus for distributing and regulating electric currents." C. D. Abel. (Communicated by Messrs. Siemens and Halske, Germany.) Dated March 1.

3679. "An improved apparatus for regulating electric currents, and for other purposes." H. H. Lake. (Communicated by E. Thomson, United States.) Dated March 1. (*Complete.*)

3687. "Improvements in apparatus for establishing electrical connection, and also for breaking the same at will at any desired distance from the operator." W. J. S. Barber-Starkey and F. G. Howard. Dated March 2.

3697. "Improvements in the construction and application of transformers for the distribution of electricity for lighting and other purposes." J. A. Kingdon. Dated March 2.

3730. "Improvements in apparatus for use with cables, when it is desired to establish electrical communication between a moored lightship, or other vessel, and some place at a distance therefrom, whether on shore or otherwise." H. M. Goodman. Dated March 2.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1887.

17902. "Improvements in apparatus for telephone exchanges." S. Pitt. (A communication from abroad by C. E. Scribner, of Chicago.) Dated December 29. 11d. Claims:—1. The grounding switch when operated by the plug, substantially as described. 2. The listening and ringing key adapted to connect and disconnect a telephone from circuit or make connection with a generator, or other source of electricity. 3. The connecting cord and plug branched from the operator's telephone circuit, and the special ringing key connected therewith to enable one operator to assist another. 4. The circuits used in connection with the apparatus above mentioned.

1888.

242. "Improvements in electrical measuring instruments." J. H. Davies. Dated January 6. 8d. The ends of a soft iron needle, or armature, project sufficiently from the spindle on which they are mounted as to allow of their coming within the influence of two coils of wire placed, diametrically opposite, one on each side of the spindle. These coils instead of being wound, as is usual, each in the same direction whereby the opposite ends of the needle, or armature, become magnetised with opposite signs (*i.e.*, one end N, and the other end S) are wound in opposite directions whereby magnetism of the same character, or sign, is induced in each of the ends of the needle, or armature, so rendering the same astatic and overcoming the tendency to be influenced by outside magnetism which exists in a needle, or armature, whose ends are differently magnetised. The claims are 3 in number.

366. "Improvements in electric arc lamps." C. D. Abel. (Communicated from abroad by the firm of Siemens & Halske, of Berlin.) Dated January 9. 8d. Claims:—1. In regulating mechanism for an electric arc lamp suspending the upper carbon from a spring barrel, or weighted pulley, which has its rotation governed by an escapement, or its equivalent, and which is mounted on a frame having its position relatively to a fixed stop governed by an electro-magnet in a shunt to the lamp circuit, so that when the resistance of the lamp is excessive, the barrel is released from the stop and the carbon descends, substantially as described. 2. In lamp regulating mechanism, such as is referred to in the preceding claim, the arrangement of the spring in combination with the pulley on the frame, and with the barrel axis, substantially as and for the purpose set forth.

1525. "Improvements relating to the distribution of electricity." L. E. Solignac. Dated February 1. 8d. Claim:—The novel system of electrical distribution, consisting in the use of electricity supplied in continuous currents, but converted into undulating currents by a single apparatus affecting the entire installation, substantially in the manner and for the purpose described and shown.

13529. "Improvements in electric meters." A. Reckenzaun. Dated September 19. 8d. Relates to electric meters in which the amount of electrical energy flowing through a given circuit in a given time is measured; and it has for its object to periodically release contact between parts of the variable speed gear employed to move the registering devices so that said parts may assume the position they should have relatively to the energy consumed. It further has for its object to compensate for the varying attractive force of a solenoid on an iron core, which, as is well known, is not always in direct proportion to the strength of the current employed. The claims are 5 in number.

14983. "Improvements in telpher lines or elevated suspended railways and vehicles and locomotives therefor." R. R. Hutchinson. Dated October 18. 8d. Has for its object the provision of a flexible track which may be suspended from or otherwise supported by posts or other means, and which admits of a greater tractive force being exerted by a light locomotive than is the case when a continuous wire or cable is employed, by reason of the structure of said flexible track affording a mechanical adhesion to the driving wheel or wheels of said locomotive, other than that resulting from the action of gravity. The claims are 6 in number.

14984. "Improved method of and apparatus for rotating hydro-extractors by means of a current of electricity, and automatically checking or arresting the motion thereof when desired." R. R. Hutchinson. Dated October 18. 8d. Relates to the application of an electric current through any suitable electric motor, for producing rotary motion at a high rate of speed of the perforated chambers of machines generally known as hydro-extractors or centrifugal drying machines. The claims are 5 in number.

14985. "Improved method of and apparatus for utilising a current of electricity for operating pile driving machinery and rendering the action of same automatic." R. R. Hutchinson. Dated October 18. 8d. Claims:—1. In a pile driver the combination and application of an electric motor with a chain or rope barrel, and suitable driving gear for transmitting the motion of said motor to said barrel, substantially as and for the purpose herein described and shown. 2. In a pile driver as referred to in the preceding claim the employment of a catch hook with a switch lever and contact bar for the purpose of making or breaking the electric circuit, substantially as described and shown in the drawings. 3. The combination of an electric motor with the hauling gear of a pile driver, and with or without the automatic electrical make and break, substantially as described and set forth.

14986. "Improved method of and apparatus for applying electricity as a motive power to cranes, sheer legs, and the like." R. R. Hutchinson. Dated October 18. 6d. Claims:—1. In a jib crane, the application of an electric motor for operating the chain barrel, with suitable gearing interposed between the spindle of said motor and said chain barrel, substantially as described and shown in the drawings. 2. The application to the hauling, raising, travelling, and swaying gear of jib and travelling cranes, and sheer legs of an electric motor or motors for the purpose of operating said gear, and obtaining the desired motion and power, substantially as described and set forth. 3. The combination of an electric motor or motors with a crane or sheer legs, either with or without an electro-magnetic brake, substantially as and for the purposes described and set forth.

14988. "Improvements in 'mashers' and 'mixers' as employed in brewing and other processes, and method of and apparatus for applying electricity as a motive power for same." R. R. Hutchinson. Dated October 18. 8d. Relates to the performance of the operation of "mashing" or mixing the grist with hot liquor, in brewing malt liquors and the like, and apparatus for applying and using electricity as a motive power therefor. The claims are 4 in number.

14989. "Improvements in steering apparatus for ships, and method of and apparatus for utilising electricity as a motive power for same." R. R. Hutchinson. Dated October 18. 8d. Relates to that class of apparatus usually employed for actuating the rudder of ships, the steersman merely moving a comparatively light wheel in order to set in motion the mechanism that moves the rudder. The claims are 4 in number.

CORRESPONDENCE.

Telephone Decisions.

A "Dogberry," still say I, a second "Dogberry." Yea, a second "Dogberry" has been developed by the study of the famous Bell Telephone Patent. In the Review of September 28th, 1888, is recorded the judicial edict of Judge Blodgett of the U. S. Circuit Court in Illinois, which fully entitled that learned and unbiased judge to the distinction of being a veritable "Dogberry," and now comes a second "Dogberry," in the person of J. Benton Hall, the present Commissioner of Patents. Your readers will recollect that the first "Dogberry" decided that "a magnetic telephone," made in 1851, containing the same elements and operating upon the same principle as the mod
Bell telephone, was "a simple acoustic telephone,
that it did not anticipate Bell's invention of 187
and now comes J. Benton Hall, Commissioner
Patents, and renders a decision in a telephone
which was argued before him more than twelve mo
ago.

The matter before the Commissioner was the p
tions of Gray and of McDonald to reopen the B
Telephone interference case in which the then Co
missioner of Patents rendered a decision in favour
Bell's patent.

The refusal of the Commissioner to reopen the c
is not criticised by me; but the statements made
the Commissioner as his reasons for his decree de
severe animadversion. I say some of them are
true, and the Commissioner had the official do
mentary evidence before him, which proves that
statement can be negatived. The Commissioner
"that it was conclusively shown in the evidence
Gray, at the time of filing his caveat, while havin
conception of the telephone, did not understand
invention, and was unable to explain the mode
its operation; that he still adhered to the idea
articulate speech must be transmitted upon the multi
telegraph principle."

That the above statement by the Commissioner
incorrect, the following extracts from the cav
filed by Gray on 14th February, 1876, the same day
which Bell filed his application for a patent, for "I
provement in Telegraphy," and in his specificati
Bell says "the advantage he claims for this method
that a very much larger number of signals can
transmitted simultaneously on the same circuit,"
patent being for a method of multiple telegraphy,
there is not one word in it which indicates that it
for telephonic purposes.

The title to Gray's caveat is: "Instruments
Transmitting and Receiving Vocal Sounds Te
graphically. Caveat filed February 14th, 1876."

In the specifications Gray says: "It is the object
my invention to transmit the tones of the human voi
through a telegraphic circuit, and reproduce the
at the receiving end of the line, so that *act*
conversations can be carried on by persons at a lo
distance apart."

The above paragraph is copied from Prescott
"Speaking telephones," page 202, to which I refer yo
and your readers.

The *World* newspaper, in a series of articles published in January last, has exposed the "fraud,"
"ignorance," "partialities" and "corruption" whic
has existed in the Patent Office during the past two year

With the dismissal of the head, which will take pla
in a few weeks, it is to be hoped that his success
will clean out the Patent Office entirely.

Throughout the length and breadth of the land ther
is great rejoicing among inventors and patent attorneys that the great obstructionist has but a few mor
days left in office.

W. C. Barney.

Washington, *March 1st*, 1889.

Telephones—A Protest.

The Consolidated Company's advertisement in you
pages is inaccurate and needs contradiction. It
absurd for the company to state that no telephones ca
be manufactured by any person or company in th
United Kingdom, other than themselves. Apart from
the various mechanical telephones, it is well know
that there are electro-magnetic telephones in th
market which are perfectly free of the United Company's patents, and may be used in the United Kingdom.
For abroad of course no one need use either the E.M
or the Consolidated patterns, as equally good telephon
can be purchased elsewhere.

The Stanhope Company, Limited.
J. S. Sawrey, *Managing Director*.

March 6th, 1889.